Fishery Data Series No. 17-34

Hugh Smith Lake Sockeye Salmon, 2016

by

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and

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August 2017

Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat or long
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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ABSTRACT

In 2016, we continued long-term sockeye salmon population studies at Hugh Smith Lake designed to evaluate adult sockeye salmon abundance and juvenile production. An estimated 32,000 sockeye salmon smolt were counted through a smolt weir operated at the outlet of the lake from 20 April to 4 June. We estimated 85% of the smolt were freshwater age-1 and 14% were freshwater age-2. From 17 June to 13 November we enumerated the adult salmon escapement through a weir; conducted an ancillary mark–recapture study to confirm the weir count; and collected biological information to estimate the age, length, and sex composition of the sockeye salmon escapement. The weir count of 12,868 adult sockeye salmon was the 12th escapement in the past 14 years to exceed the lower bound of the optimal escapement goal range of 8,000–18,000 adult sockeye salmon. Age-1.3 adults were the dominant returning age class, representing an estimated 67% of the total spawning population. A count of 1,810 live spawners was observed in Buschmann Creek on 15 September. The reported subsistence harvest (404 fish) was the fifth largest harvest on record. Results from genetic stock identification analysis were used to estimate the contribution of Hugh Smith Lake sockeye salmon to southern Southeast Alaska commercial net fisheries. We estimated 35,600 Hugh Smith Lake fish were harvested in District 101–108 net fisheries in 2016 at an estimated commercial harvest rate of 73%.

Key words: escapement, Hugh Smith Lake, mark–recapture, *Oncorhynchus nerka*, optimal escapement goal, sockeye salmon, stock of concern, harvest rate

INTRODUCTION

Located southeast of Ketchikan, Alaska, in Boca de Quadra Inlet, Hugh Smith Lake has been an important sockeye salmon (*Oncorhynchus nerka)* contributor to southern Southeast Alaska commercial fisheries for over a century. Intense fisheries in the late 1800s and early 1900s supplied a saltery adjacent to the Hugh Smith Lake estuary and two canneries in Boca de Quadra Inlet (Rich and Ball 1933; Roppel 1982). A private hatchery was operated at the head of the lake on Hatchery Creek from 1901 to 1903 and also from 1908 to 1935, but numbers of adult sockeye salmon returning to the lake were not recorded (Roppel 1982). Egg take records suggest 3,000–6,000 females were collected annually for broodstock from Buschmann Creek, one of the primary spawning tributaries (Roppel 1982). Moser (1898) concluded that despite overfishing, Hugh Smith Lake should produce annual runs of 50,000 sockeye salmon under average conditions.

The Alaska Department of Fish and Game (ADF&G) has monitored adult escapements through a weir at the outlet of Hugh Smith Lake from 1967 to 1971 and annually since 1980. Beginning in the early 1980s, the lake was the subject of ADF&G enhancement and rehabilitation efforts that included nutrient enrichment from 1981 to 1984, and fry plants from 1986 to 1997 (Geiger et al. 2003). The vast majority of juveniles from these early stocking programs were not thermal marked, so detailed information on the proportion of stocked fish in subsequent escapements is unavailable. Despite lake enrichment and enhancement efforts, total escapements steadily declined from an average of 17,500 fish in the 1980s to 12,000 fish in the 1990s. Escapements averaged only 3,500 fish from 1998 to 2002, including the smallest escapement on record in 1998 (1,138 fish).

In 2003, the Alaska Board of Fisheries classified Hugh Smith Lake sockeye salmon a stock of management concern (5 AAC 39.222) due to the long-term decline in escapement (Geiger et al. 2003). Based on escapement goal analyses outlined in Geiger et al. (2003) the board set an optimal escapement goal of 8,000–18,000 sockeye salmon (5 AAC 33.390) to include spawning salmon of wild and hatchery origin. They also adopted an action plan that directed ADF&G to review stock assessment and rehabilitation efforts at the lake, and implement conservation measures to reduce commercial harvests of Hugh Smith Lake sockeye salmon when projected escapements were below the lower end of the escapement goal range. Fishery restrictions, in the form of time and area closures, affected the commercial net fisheries closest to the entrance of Boca de Quadra (Figure 1). At that time, the only existing rehabilitation effort at the lake was Southern Southeast Regional Aquaculture Association's (SSRAA) stocking program, which was intended to boost adult escapements. Eggs were collected from Buschmann Creek then reared and thermal marked at Burnett Inlet Hatchery. Each spring, from 1999 through 2003, thermal marked fry were returned to Hugh Smith Lake and fed in net pens to presmolt size until they were released in summer.

ADF&G estimated the contribution, distribution, and run timing of stocked Hugh Smith Lake sockeye salmon in the commercial net fisheries from recoveries of marked fish from 2003 to 2007. Results from this project showed that fisheries management restrictions outlined in the action plan were appropriately timed and located to reduce harvests on this stock (Heinl et al. 2007). Additionally, ADF&G conducted studies to identify factors that might limit juvenile sockeye salmon survival at various stages of their early life history; however, these studies did not identify any factors in the freshwater environment that would increase mortality of juvenile sockeye salmon (Piston et al. 2006 and 2007; Piston 2008). Adult escapements steadily improved from a low of 1,138 fish in 1998 to 42,529 fish in 2006 (Piston et al. 2007); however, fish from the SSRAA stocking program made up a significant portion (58–65%) of escapements from 2003 to 2007 (Heinl 2007; Piston 2008). The stock of concern status was removed in 2006 due to an improvement in escapements (Geiger et al. 2005), and escapements surpassed the lower bound of the escapement goal in 11 of 13 years, 2003–2015 (Brunette and Piston 2016).

Population studies at Hugh Smith Lake provide the longest time series (1982–2015) of escapement and age, sex, and length (ASL) information for both sockeye and coho (*O. kisutch*) salmon (Shaul et al. 2009) in southern Southeast Alaska. Thus, these important wild salmon indicator stocks provide information useful for managing southern Southeast Alaska fisheries. In 2016, we estimated sockeye salmon smolt abundance at the smolt weir in the spring, and we estimated the adult escapement at the adult weir in summer and early fall to determine if the escapement goal was met. We also conducted an ancillary mark–recapture study to provide a secondary escapement estimate if the adult weir failed. ASL data were collected from a subset of out-migrating sockeye salmon smolt and returning adults at the weirs, and biweekly foot surveys were conducted on both inlet streams to count spawning salmon. We used the stock separation results from genetic stock identification (GSI) analysis to estimate the commercial harvest of Hugh Smith Lake sockeye salmon in southern Southeast Alaska net fisheries in 2016. Estimates of the commercial harvest, combined with the reported subsistence harvest and annual escapement counts, were used to estimate the total run and harvest rate.

STUDY SITE

Hugh Smith Lake (55° 06′ N, 134° 40′ W; Orth 1967) is located on mainland Southeast Alaska, 67 km southeast of Ketchikan in Misty Fjords National Monument (Figure 1). The lake is organically stained and covers a surface area of 320 ha. It has a mean depth of 70 m, a maximum depth of 121 m, and a volume of 222.7×10^6 m^3 (Figure 2). Hugh Smith Lake empties into Boca de Quadra Inlet via 50-m-long Sockeye Creek (ADF&G Anadromous Waters Catalog number 101-30-10750). Sockeye salmon spawn in two inlet streams: Buschmann Creek flows northwest 4 km to the head of the lake (ADF&G Anadromous Waters Catalog number 101-30-10750-2006, "Beaver Pond Channel" 101-30-10750-3003); and Cobb Creek flows north 8 km to the southeast head of the lake (ADF&G Anadromous Waters Catalog number 101-30-10750-2004; Figure 2). Cobb Creek has a barrier to anadromous migration approximately 0.8 km upstream from the lake. Hugh Smith Lake is meromictic and the upper freshwater layer does not interact with the lower saltwater layer below 60 m.

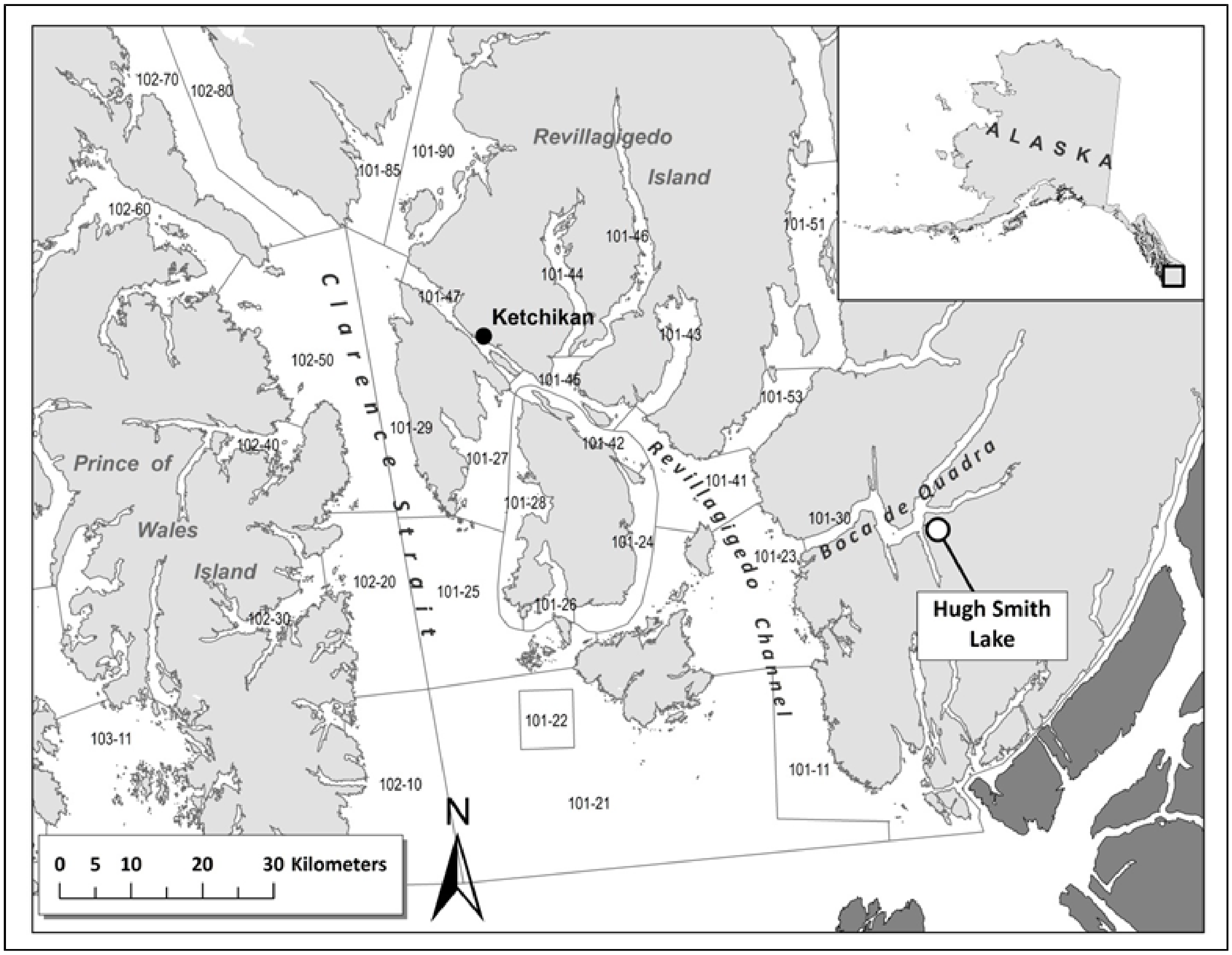

Figure 1.–The location of Hugh Smith Lake in Southeast Alaska.

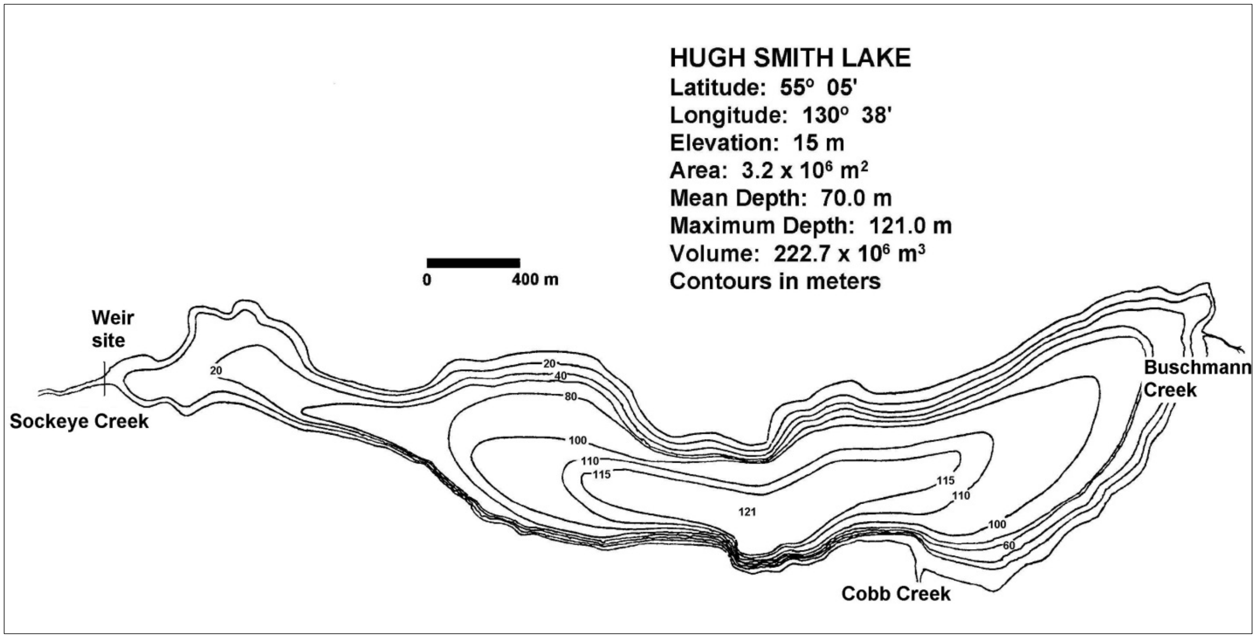

Figure 2.–Bathymetric map of Hugh Smith Lake showing the weir location above the outlet stream, the two primary inlet streams, and other features of the lake system.

METHODS

SMOLT OUTMIGRATION

Since 1982, Hugh Smith Lake coho and sockeye salmon smolt have been counted and sampled through a smolt weir as they emigrate each spring (Shaul et al. 2009 provided a physical description of the weir). In 2016, the smolt weir was operated from 20 April to 4 June. Fish were counted through the weir by species and scale samples and length-weight data were collected daily. Scale samples were collected from 16 sockeye salmon smolt on days when fewer than 100 sockeye salmon smolt were captured at the weir, and from 28 sockeye salmon smolt on days when 100 or more fish were captured. Typically, the first 16 or 28 smolt dipnetted out of the trap were sampled. The snout-to-fork length (in mm) and total weight (to the nearest 0.1 g) were recorded, and a scale smear from the preferred-area (Clutter and Whitesel 1956) was collected from each fish sampled. Scales were placed on a 2.5 cm × 7.5 cm glass microscope slide, four fish per slide, and aged at the Ketchikan ADF&G office using a video-linked microscope.

Total smolt weir counts have underestimated the true smolt population size due to fish escaping past the weir uncounted and leaving the system before and after the weir is installed. An unknown but presumably small number of smolt also passed through a deep, conical opening designed to provide adult steelhead free upstream passage through the weir. Hugh Smith Lake coho salmon smolt tagging data from 1982 to 2006 showed that capture rate at the smolt weir was highly variable, ranging from 14% to 84%. Improvements made to prevent smolt from passing the weir uncounted increased capture efficiency to an average 70% for coho salmon smolt from 1996 to 2006 (Shaul et al. 2009).

ADULT ESCAPEMENT

Weir Counts

ADF&G operated an adult salmon counting weir at the outlet of the lake, approximately 50 m from saltwater, from 1967 to 1971 and annually since 1980. In 2016, the weir was operated from 17 June to 13 November and periodic underwater inspections were conducted to verify the integrity of the weir. The weir was an aluminum bi-pod, channel-and-picket design with an upstream trap divided into two sections: a smaller section exclusively for counting salmon, and a larger section for both counting and sampling salmon.

As part of long-term coho salmon coded-wire-tagging studies at Hugh Smith Lake (Shaul et al. 2005 and 2009), every coho salmon counted at the weir had to be examined for an adipose fin and a coded-wire tag (Shaul and Crabtree 2014). Guillotine gates installed on the upstream sides of both trap sections allowed us to visually identify and count fish as they swam unimpeded into the lake or quickly close the trap when a coho salmon, or other fish of interest, was identified. Fish passage through the gates was also recorded using an underwater video camera, and the recordings were reviewed daily to verify the visual weir count. If a coho salmon passed through the gates unexamined, we reviewed the video recording to determine whether its adipose fin was present. This method allowed us to efficiently pass 90% of all salmon into the lake without introducing additional handling stress while meeting the sampling goals of the ongoing coho salmon study. Fish not passed freely through the gates were dipnetted out of the sampling trap, anesthetized, marked, sampled, and released upstream in front of the weir.

In order to encourage fish movement through the weir during periods of low water, we applied 6 mil plastic sheeting to the upstream face of the weir to concentrate the stream flow through the trap. The resultant increase in current prompted fish to move upstream and reduced their holding time below the weir (Piston and Brunette 2010).

Mark–recapture

Two-sample mark–recapture studies are essential to estimating the adult sockeye salmon escapement at Hugh Smith Lake. Mark–recapture estimates are used to verify the weir count if fish passed the weir uncounted during extreme flood events, or if substantial numbers of sockeye salmon entered the lake before the weir was fish tight in mid-June. Ten percent of adult sockeye salmon (fish >400 mm in length) were anesthetized in a clove oil solution at the weir (Woolsey et al. 2004) and marked with a readily identifiable fin clip. Visibly unhealthy fish were not marked. Marking was stratified through time by applying fin clips on the following schedule: right pelvic fin clip from 18 June to 22 July, left pelvic fin clip from 23 to 31 July, and a partial dorsal fin clip from 1 August to 3 November. We did not conduct a mark–recapture study for jack sockeye salmon (<400 mm) since most can swim freely between the weir pickets and relatively few are trapped. In previous years, we have been unable to mark and recover enough fish to obtain a valid population estimate for jack sockeye salmon.

Weekly surveys were conducted at Buschmann and Cobb creeks beginning the last week of August to sample spawners for marks. Live fish were captured using a beach seine off the creek mouth or dip nets in the spawning channels. All carcasses found on stream surveys were also examined for marks. Each fish examined was recorded as either unmarked (no fin clip) or by its mark type (right or left pelvic, or partial dorsal fin clip), and given a secondary mark (a small paper hole punch through the left operculum) to prevent resampling. Our goal was to examine at least 600 sockeye salmon over the entire spawning season. A sample size of 600 fish in the second sampling event should yield a population estimate with a coefficient of variation less than 15% when a population of nearly 10,000 (recent 10-year average escapement) is marked at a 10% rate (Robson and Regier 1964).

We used Stratified Population Analysis System (SPAS) software (Arnason et al. 1996) to generate mark–recapture estimates of the total spawning population of sockeye salmon. Based on work by Chapman and Junge (1956), Darroch (1961), Seber (1982), and Plante (1990), SPAS was designed to analyze two-sample mark–recapture data where marks and recoveries take place over a number of strata. This software was used to calculate: 1) maximum likelihood (ML) Darroch estimates and pooled-Petersen (Chapman's modified) estimates, and their standard errors; 2) χ^2 tests for goodness-of-fit based on the deviation of predicted values (fitted by the ML Darroch estimate) from the observed values; and 3) two χ^2 tests of the validity of using fully pooled data—a test of complete mixing of marked fish between release and recovery strata, and a test of equal proportions of marked fish in the recovery strata. If the result of either of the χ^2 test of complete mixing or the χ^2 test of equal proportions was not significant ($P > 0.05$), we typically chose to pool data (i.e., the pooled-Petersen estimate). Our goal was to estimate the escapement such that the coefficient of variation was no greater than 15% of the point estimate. The manipulation of release and recovery strata in calculating estimates (the method used in SPAS) was presented and discussed at length by Schwarz and Taylor (1998). When ML Darroch estimates failed to converge, data were pooled until an estimate was obtained.

The weir count was used as the official escapement estimate if it fell within the transform-based 95% confidence interval of the mark–recapture estimate. This was the same criterion used in previous years (Geiger et al. 2003). The escapement goal was met if the weir count fell within the escapement goal range and was within the 95% confidence interval of the mark–recapture estimate. The goal would not have been met if both the weir count and the mark–recapture estimate were below the lower bound of the escapement goal range. In the case where one or the other estimate fell within the escapement goal range, the weir count would be used as the official escapement estimate, unless the weir count was below the lower bound of the 95% confidence interval of the mark–recapture estimate. We chose to use the mark–recapture "point" estimate for the purpose of judging the escapement objective.

Adult Age, Sex, and Length Composition

Based on work by Thompson (1992), scale samples from 510 fish were needed to ensure the estimated proportion of each adult sockeye salmon age class would be within 5% of the true value 95% of the time. We increased the sample goal to 600 scale samples to account for a small proportion (<15%) of unreadable scales. Scale samples were collected at the weir from 1 out of every 10 fish (10%). Mid eye to tail fork (MEF) length and sex data were recorded for each fish sampled. Fish less than 400 mm were counted as jacks and not included in the adult sockeye salmon age composition sample. Three scales were collected from the preferred area (INPFC 1963) on the left side of the fish, two scale rows above the lateral line on the diagonal from the posterior insertion of the dorsal fin to the anterior insertion of the anal fin, placed on a gum card, and prepared for analysis as described by Clutter and Whitesel (1956). Scales were analyzed at the ADF&G salmon-aging laboratory in Douglas, Alaska. The weekly age distribution, seasonal age distribution weighted by week, and the mean length by age and sex weighted by week were calculated using equations from Cochran (1977; Appendix B).

STREAM COUNTS

Live and dead salmon were counted, by species, during surveys of Buschmann and Cobb creeks. Cobb Creek was surveyed from the mouth to the barrier falls (0.8 km; 55° 05.35 N, 130° 38.673 W). Buschmann Creek was typically surveyed to the top of the Hatchery Channel on the right fork, and to the Beaver Pond channel on the left fork (Figure 3). Effort was focused on areas with the highest flow and abundance of spawning fish.

What we have generally called Buschmann Creek actually consists of two separate creeks, draining two separate valleys, which meet in their lower reaches. The stream flowing from the southeast valley is Buschmann Creek and the tributary flowing out of the northeast valley is the "Beaver Pond Channel" (Figure 3).

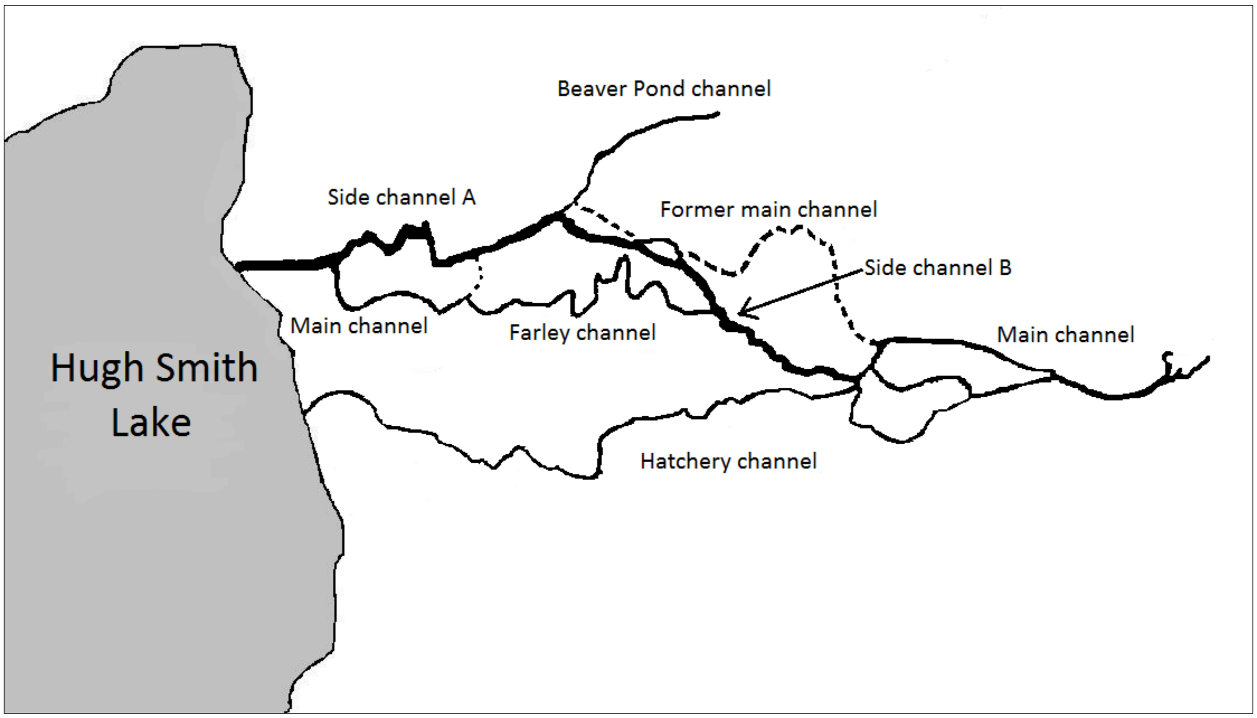

Figure 3.–Schematic diagram of the main flow of lower Buschmann Creek, as of September 2016. Dashed lines indicate channels that did not have adequate water flow to accommodate spawning salmon.

HARVEST

Commercial Fisheries

The commercial harvest of Hugh Smith Lake sockeye salmon was estimated through genetic stock identification methods. Laboratory analysis, including quality control, was performed by the ADF&G Gene Conservation Laboratory (GCL) in Anchorage, Alaska, following methods outlined in Dann et al. (2012), or by the National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service, Alaska Fishery Science Center, Auke Bay Laboratories, Ted Stevens Marine Research Institute using methods outlined in Guthrie et al. (2015). Stock composition estimates for the District 101–103 purse seine fisheries were computed by the GCL, and estimates for the District 104 purse seine and District 101 drift gillnet fisheries were computed by the NOAA Auke Bay Laboratory. Both labs used the Bayesian mixed stock analysis (MSA) approach in the program BAYES (Pella and Masuda 2001, Rogers Olive et al. *In prep*). Stock composition estimates for the District 106 and 108 drift gillnet fisheries were computed by the GCL using a method that incorporates ages from matched scales and hatchery thermal marks on matched otoliths to help inform the genetic estimates. This method ("mark- and age-enhanced GSI") requires two sets of parameters: 1) a vector of stock compositions, summing to one, with a proportion for each of the wild and hatchery stocks weighted by harvest per stratum; and 2) a matrix of age composition, with a row for each of the wild and hatchery stocks (summing to one), and a column for each age class. This method utilizes all available information to assign individuals to stock of origin based on age, genotype, and/or otolith information.

Tissue samples were collected at the major fish processing ports in Southeast Alaska by the ADF&G Port Sampling program to facilitate management of commercial fisheries and fulfill obligations under the Pacific Salmon Treaty. Sample sizes were primarily designed to determine the harvest contribution by country of origin in the boundary area fisheries; specifically, the estimated contribution of Alaska sockeye salmon, and British Columbia Nass and Skeena river sockeye salmon. Sockeye salmon bound for Hugh Smith Lake can be identified using MSA (Rogers Olive et al. *In prep*); however, to maintain precision and accuracy for single population reporting groups, it has been ADF&G's guideline to only report estimates when the expected number of fish in a mixture is 5% or more. Estimated proportions of Hugh Smith Lake sockeye salmon in weekly harvests were less than 5% in all fisheries sampled outside of District 101, so to provide the most accurate estimates for purse seine fisheries in Districts 102 and 103, and drift gillnet fisheries in Districts 106 and 108, weekly strata were pooled and weighted by the harvest to generate total season estimates following Jasper et al. (2012a and 2012b). It was not possible to pool purse seine fisheries in District 104, so estimates are provided for each weekly stratum. We report point estimates as well as standard deviations and credibility intervals as outputs of BAYES. Harvest estimates for all fisheries over a year were calculated by multiplying the estimated proportion by the respective harvest for each stratum, then summing across all strata. Standard deviations across all strata in a year were derived by calculating the sum of squares to estimate variance, and taking the square root of this value. The standard deviation was multiplied by 1.645 to calculate 90% confidence intervals over all fisheries. Commercial harvest rates were calculated by dividing the total commercial harvest by the sum of commercial harvest and escapement.

Sampling effort spanned the historical peak weeks of sockeye salmon harvests in southern Southeast Alaska traditional net fisheries (Districts 101–108): statistical weeks 25 through 35 (approximately mid-June to late August; Table 1; Appendix A). On average, 99% of the sockeye salmon harvest in southern Southeast Alaska occurred during that period. Established ADF&G Port Sampling procedures ensured that weekly samples were as representative of a specific district harvest as possible. Only harvests originating from a single fishing district and gear type were sampled. No more than 40 tissue samples were collected from each individual boat's harvest and no more than 200 tissue samples were collected from each tender (Buettner et al. 2017). When individual seine boats caught fewer than 40 total sockeye salmon, tissues were collected from every sockeye salmon on board. When possible, samples were collected from the entire hold in order to best represent all sockeye salmon in that delivery. Additionally, samples were collected from multiple deliveries from each fishing district over the entire statistical week as much as possible. Total weekly harvest was obtained from the ADF&G fish ticket database.

Table 1.–Weekly sockeye salmon tissue sample goals for southern Southeast Alaska net fisheries, 2016.

District and fishery	Weekly sample target	Statistical weeks	Annual sample goal
101 Purse Seine	260	29–35	1,820
102 Purse Seine	260	26–35	2,600
103 Purse Seine	–	28–35	390
104 Purse Seine	260	28–35	2,080
101-11 Drift Gillnet	260	26–35	2,600
106-30 Drift Gillnet	300	25–35	3,300
106-41 Drift Gillnet	300	25–35	3,300
108 Drift Gillnet (Subdistricts 30 and 40)	260	25–34	2,600
108 Drift Gillnet (Subdistricts 50 and 60)	260	25–34	2,600
Grand Total	2,160		21,290

Subsistence Fishery

Hugh Smith Lake sockeye salmon are harvested in the Sockeye Creek subsistence fishery that, by regulation (5 AAC 01.716(a)(1)(B)(ii)), takes place "within 500 yards of the terminus of Sockeye Creek" at the estuary confluence with Boca de Quadra, and at least "300 feet below the weir" (5 AAC 01.010(e)). Fishery participants were required to obtain an ADF&G-issued Personal Use and Subsistence Fishing permit prior to fishing, and to return their permit with a detailed harvest record by 10 November 2016 even if they did not fish. In 2016, the fishery was open from 22 June to 31 July and permitted fishers were allowed to retain 12 sockeye salmon daily with no annual limit. Reported subsistence harvest and effort has been based entirely on the cooperation of fishery participants; however, reported subsistence harvests here and elsewhere in the region (Conitz and Cartwright 2005; Conitz 2008; Walker 2009) probably underrepresent the true harvest because not all permits are returned (e.g., 13–32% of Subsistence and Personal Use permits for the Ketchikan Area were not returned, 1985–2015), and those that are returned may underreport the actual number of fish harvested. Subsistence fishery harvest rates were calculated by dividing the reported subsistence harvest by the total terminal run (sum of subsistence harvest and escapement).

RESULTS

SMOLT OUTMIGRATION

An estimated 32,000 sockeye salmon smolt were counted through the smolt weir between 20 April and 4 June (Figure 4; Table 2). On 19 April the surface water temperature was 7°C (2°C warmer than the historical average of 5°C), and 50 sockeye salmon smolt were caught in the trap before the weir was fish tight. The peak daily count (6,500 fish) occurred on 2 May, and more than 13,000 smolt were counted 2–5 May. Nearly 700 sockeye salmon smolt were killed 2–4 May, when high water trapped them against the smolt weir. A freshet in the following week (8–10 May) prompted another large pulse of smolt to emigrate. Fewer sockeye salmon smolt were killed (225 fish) during this second event because plastic sheeting was applied to the weir to protect smolt and help guide them toward the trap. Numbers of emigrating sockeye salmon smolt declined after 10 May to fewer than 1,000 fish per day until the weir was removed on 4 June.

We collected 1,010 scale samples from sockeye salmon smolt and determined the freshwater age composition, weighted by week, to be 85% age-1 and 14% age-2 (Table 2, Figure 5). Mean lengths by age class were 75 mm for age-1 and 100 mm for age-2 smolt. Mean weights by age class were 3.7 g for age-1 and 8.7 g for age-2 smolt (Table 3).

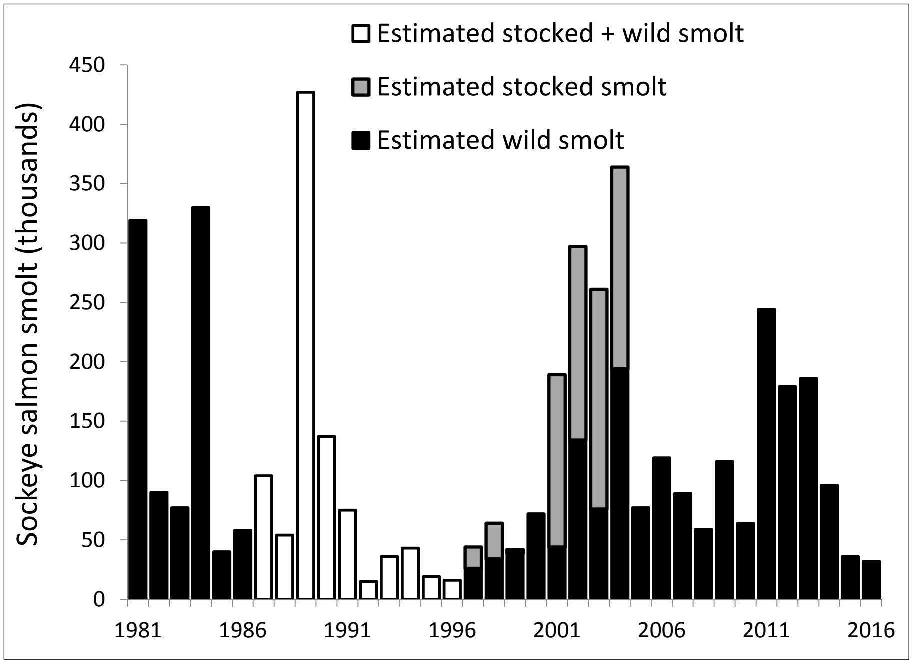

Figure 4.–Annual smolt weir counts at Hugh Smith Lake, 1981–2016. Divided bars show estimates of wild (black) and stocked (grey) smolt for years in which proportions of stocked smolt were estimated from otolith samples collected at the weir (1997–1999 and 2001–2004). Stocked fish released prior to 1996 were unmarked.

Table 2.–Hugh Smith Lake sockeye salmon smolt counts, hatchery releases, and freshwater age composition, 1981–2016. Proportions of stocked smolt were determined from otolith samples collected at the weir.

Release year	Hatchery release numbers	Release type	Smolt year	Total smolt counted	Freshwater age Percent of total Age 1	Age 2	Age 3	Wild smolt	Stocked smolt	Percent stocked
1980	-	-	1981	319,000	71%	29%	0%	319,000	-	-
1981	-	-	1982	90,000	83%	18%	0%	90,000	-	-
1982	-	-	1983	77,000	60%	40%	0%	77,000	-	-
1983	-	-	1984	330,000	92%	8%	0%	330,000	-	-
1984	-	-	1985	40,000	51%	48%	1%	40,000	-	-
1985	-	-	1986	58,000	73%	24%	3%	58,000	-	-
1986	273,000	Unfed Fry	1987	105,000	42%	57%	1%	-------	ND[a]	-------
1987	250,000	Unfed Fry	1988	54,000	65%	35%	0%	-------	ND	-------
1988	1,206,000	Unfed Fry	1989	427,000	83%	17%	0%	-------	ND	-------
1989	532,800	Unfed Fry	1990	137,000	31%	68%	2%	-------	ND	-------
1990	1,480,800	Unfed Fry	1991	75,000	64%	36%	0%	-------	ND	-------
1991	-	-	1992	15,000	42%	57%	1%	-------	ND	-------
1992	477,500	Fed Fry	1993	36,000	63%	36%	2%	-------	ND	-------
1993	-	-	1994	43,000	75%	21%	4%	-------	ND	-------
1994	645,000	Unfed Fry	1995	19,000	38%	62%	0%	-------	ND	-------
1995	418,000	Unfed Fry	1996	16,000	44%	40%	16%	-------	ND	-------
1996	358,000	Unfed Fry/ Presmolt[b]	1997	44,000	52%	40%	8%	26,000	18,000	40%
1997	573,000	Unfed Fry[b]	1998	65,000[c]	81%	18%	1%	34,000	30,000	47%
1998	-	-	1999	42,000	68%	32%	0%	39,000	3,000	4%
1999	202,000	Presmolt[d]	2000	72,000	77%	22%	1%	-------	ND	-------
2000	380,000	Presmolt[d]	2001	189,000	91%	8%	1%	44,000	145,000	77%
2001	445,000	Presmolt[d]	2002	297,000	88%	12%	0%	134,000	163,000	55%
2002	465,000	Presmolt[d]	2003	261,000	86%	14%	0%	76,000	185,000	71%
2003	420,000	Presmolt[d]	2004	364,000	88%	12%	0%	194,000	170,000	47%
2004	-	-	2005	77,000	54%	46%	0%	77,000	-	-
2005	-	-	2006	119,000	63%	36%	1%	119,000	-	-
2006	-	-	2007	89,000	71%	27%	2%	89,000	-	-
2007	-	-	2008	59,000	62%	37%	1%	59,000	-	-
2008	-	-	2009	116,000	40%	59%	1%	116,000	-	-
2009	-	-	2010	64,000	19%	79%	2%	64,000	-	-
2010	-	-	2011	244,000	89%	10%	1%	244,000	-	-
2011	-	-	2012	179,000	72%	28%	0%	179,000	-	-
2012	-	-	2013	186,000	74%	26%	0%	186,000	-	-
2013	-	-	2014	95,000	71%	29%	0%	95,000	-	-
2014	-	-	2015	36,000	53%	47%	0%	36,000	-	-
2015	-	-	2016	32,000	85%	14%	1%	32,000	-	-

[a] ND indicates “no data”.

[b] In 1996, Southern Southeast Regional Aquaculture Association released 251,123 unfed fry into the lake in May and 106,833 presmolt in October. All fish released in 1996 and 1997 were thermal marked.

[c] In 1998, the total smolt count does not equal the sum of wild and stocked smolt due to rounding.

[d] From 1999–2003, fry were pen-reared at the outlet of the lake beginning in late May and released as presmolt in late July and early August. All fish from those releases were thermal marked.

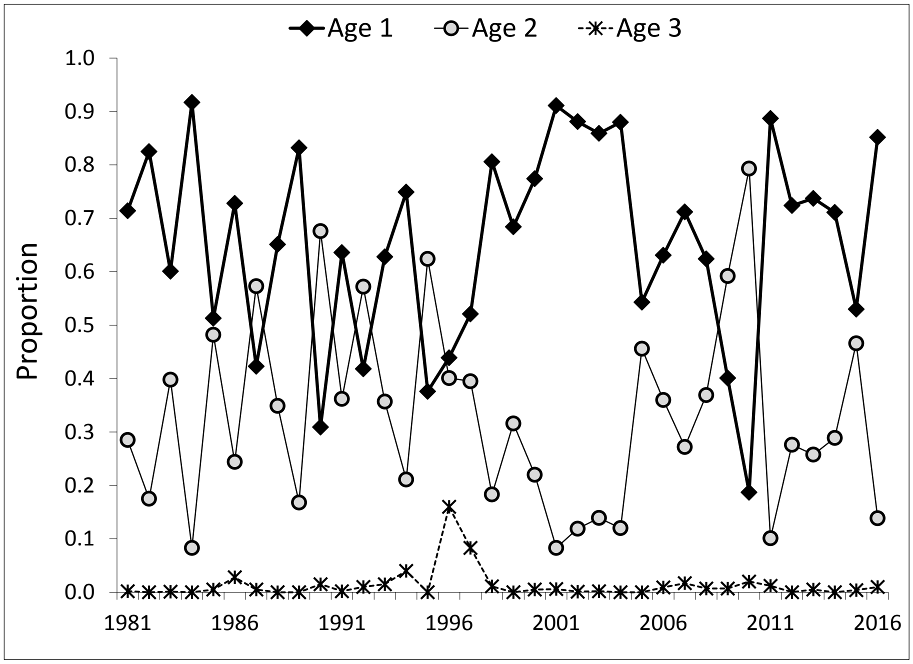

Figure 5.–Age composition of sockeye salmon smolt at Hugh Smith Lake, 1981–2016.

Table 3.–Lengths and weights of sockeye salmon smolt by freshwater age, weighted by week, 2016.

	Smolt freshwater age		
	Age-1	Age-2	Age-3
Number sampled	903	101	6
Mean length (mm)	75	100	128
Standard error (mm)	0.3	1.2	9.8
Maximum length (mm)	95	122	127
Minimum length (mm)	61	77	99
Number sampled	903	101	6
Mean weight (g)	3.7	8.7	22.2
Standard error (g)	0.0	0.3	5.2
Maximum weight (g)	6.6	15.6	18.0
Minimum weight (g)	1.6	3.6	8.7

ADULT ESCAPEMENT

Weir and Stream Counts

The adult weir was operated from 17 June to 13 November, during which time 12,868 adult sockeye salmon and 93 jacks were counted into the lake (Appendix C). This was the tenth year of the past 12 years that the optimal escapement goal range of 8,000–18,000 sockeye salmon was met exclusively with wild fish (Figure 6). The midpoint of the run occurred on 27 July and the 75th percentile of the run occurred on 13 August. On 15 September, 1,810 live sockeye salmon were counted in Buschmann Creek.

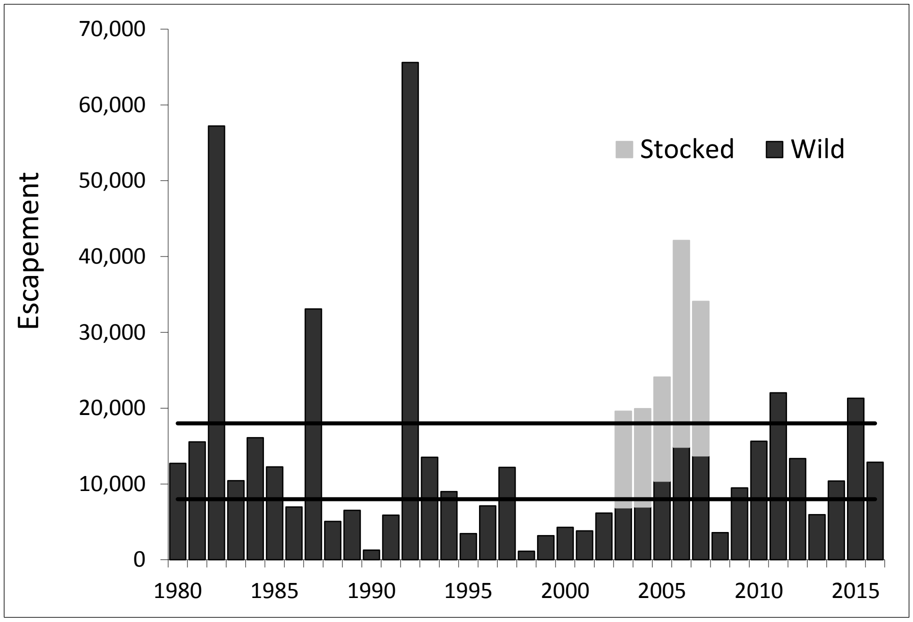

Figure 6.–Annual sockeye salmon escapement at Hugh Smith Lake, 1980–2016. Black horizontal lines indicate the current optimal escapement goal range of 8,000–18,000 adult sockeye salmon, which includes both wild and hatchery stocked fish. From 2003 to 2007, the bars are divided to show our estimate of wild (black) and stocked fish (grey) in the escapement. Fry stocked from 1986 to 1997 were thought to have experienced very low survival rates with few surviving to emigrate from the lake (Geiger et al. 2003). Contribution estimates of wild and stocked fish are not available for years prior to 2003.

Mark–recapture

A total of 1,297 adult sockeye salmon were marked at the weir over three marking strata: 78 fish were marked with a right ventral fin clip (24 June–22 July), 627 fish were marked with a left ventral fin clip (23–31 July), and 592 fish were marked with a partial dorsal fin clip (1 August–3 November). Recapture sampling was conducted on the spawning grounds from 27 August to 17 September. Out of 1,008 fish inspected for marks, 94 fish were marked with a fin clip (Table 4). The result of the χ^2 test for complete mixing of marked fish between the marking and recapture events was significant (P = 0.00); however, the result of the χ^2 test for equal proportions of marked fish on the spawning grounds was not significant (P = 0.52). The pooled-Petersen mark–recapture estimate was 13,785 adult sockeye salmon (SE = 1,289; 95% transform-based CI = 11,538–16,655 fish; Appendix D). The weir count of 12,868 sockeye salmon fell within the 95% confidence interval of the pooled-Peterson estimate and was used as the official escapement estimate.

Table 4.–Number of fish inspected for marks by release stratum for the adult sockeye salmon mark–recapture study, 2016.

Date	Sampling location	Marked fish			Unmarked fish	Total examined
		Right pelvic fin	Left pelvic fin	Dorsal fin		
27-Aug	Buschmann creek	1	0	0	29	30
29-Aug	Buschmann creek	7	11	0	158	176
3-Sept	Buschmann creek	2	9	0	123	134
5-Sept	Cobb creek	0	2	0	12	14
12-Sept	Buschmann creek	2	9	8	150	169
14-Sept	Buschmann creek	0	13	3	188	204
17-Sept	Buschmann creek	3	18	6	254	281
	Total	15	62	17	914	1,008

Adult Age, Sex, and Length Composition

Based on scale pattern analysis, 21% of the escapement was 2-ocean fish (2,674 sockeye salmon) and 79% was 3-ocean fish (10,179 sockeye salmon; Figures 7 and 8; Appendix E). The most abundant adult age classes were age-1.3 fish (67%), followed by age-1.2 fish (12.8%) and age-2.3 fish (12.5%; Table 5). Of the 619 readable scale samples collected, one fish was identified as an ocean-age-4 adult (Table 5).

Average lengths-at-age for ocean-age-3 fish in 2016 were among the smallest in the 35-year record. Males age-1.3 were 20 mm shorter than the historical average (1982–2015), and males age-2.3 were 17 mm shorter than average. Both age-1.3 and -2.3 males were the third shortest on record (Figure 9). Females age-1.3 were 11 mm shorter than average and the 7th smallest on record, and females age-2.3 were 16 mm shorter than average and the 6th smallest on record (Figure 10).

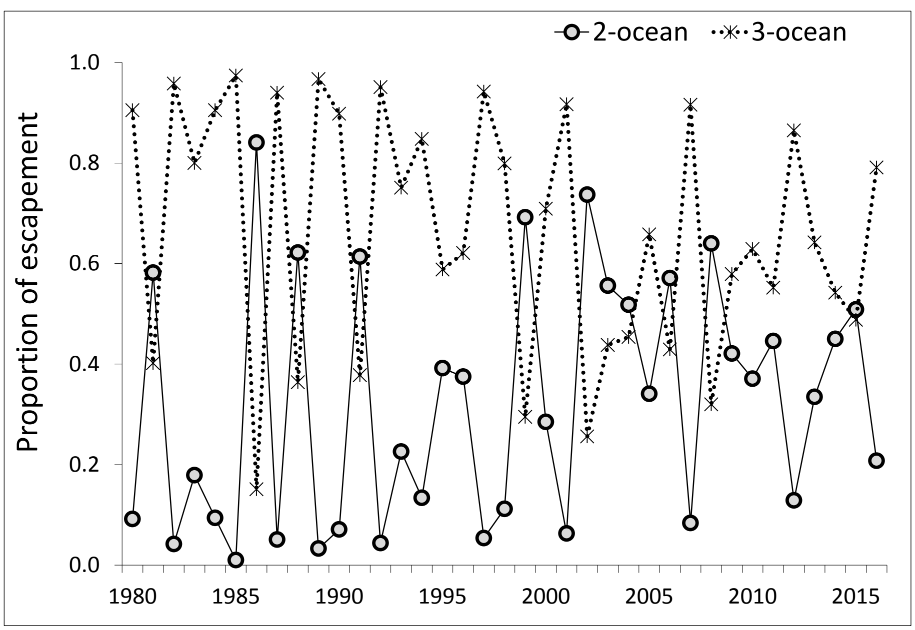

Figure 7.–Annual proportions of ocean-age-2 and -3 sockeye salmon in the Hugh Smith Lake escapement, 1980–2016.

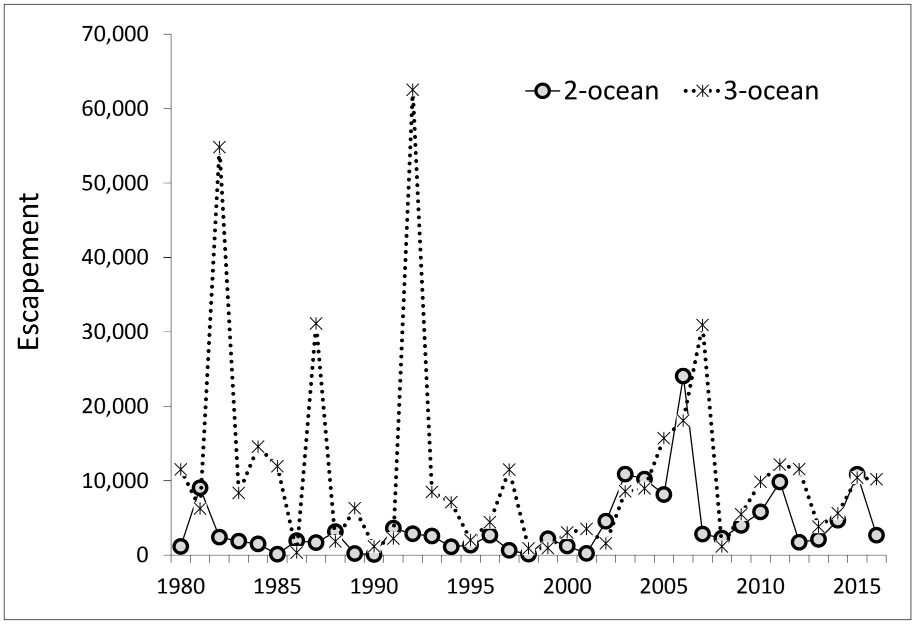

Figure 8.–Annual number of ocean-age-2 and -3 sockeye salmon in the Hugh Smith Lake escapement, 1980–2016.

Table 5.–Age composition of the 2016 adult sockeye salmon escapement at Hugh Smith Lake based on scale pattern analysis, weighted by statistical week.

Stat. week		Ocean-age-2		Ocean-age-3		Ocean-age-4	
		1.2	2.2	1.3	2.3	1.4	Total
26–28	*n*	5	0	24	0	0	29
	Proportion	17.2%	0.0%	82.8%	0.0%	0.0%	100%
	SE of %	6.8%	0.0%	6.8%	0.0%	0.0%	
	Number in Esc.	55	0	263	0	0	
29–30	*n*	4	1	35	2	0	42
	Proportion	9.5%	2.4%	83.3%	4.8%	0.0%	100%
	SE of %	4.4%	2.3%	5.6%	3.2%	0.0%	
	Number in Esc.	45	11	395	23	0	
31	*n*	44	6	324	35	1	410
	Proportion	10.7%	1.5%	79.0%	8.5%	0.2%	100%
	SE of %	1.5%	0.6%	1.9%	1.3%	0.2%	
	Number in Esc.	664	91	4,891	528	15	
32	*n*	4	0	18	3	0	25
	Proportion	16.0%	0.0%	72.0%	12.0%	0.0%	100%
	SE of %	7.3%	0.0%	8.9%	6.5%	0.0%	
	Number in Esc.	74	0	333	55	0	
33	*n*	5	5	34	13	0	57
	Proportion	8.8%	8.8%	59.6%	22.8%	0.0%	100%
	SE of %	3.7%	3.7%	6.5%	5.5%	0.0%	
	Number in Esc.	236	236	1,608	615	0	
34	*n*	0	3	17	3	0	23
	Proportion	0.0%	13.0%	73.9%	13.0%	0.0%	100%
	SE of %	0.0%	7.1%	9.3%	7.1%	0.0%	
	Number in Esc.	0	168	952	168	0	
35	*n*	3	2	1	1	0	7
	Proportion	42.9%	28.6%	14.3%	14.3%	0.0%	100%
	SE of %	20.0%	18.3%	14.2%	14.2%	0.0%	
	Number in Esc.	168	112	56	56	0	
36	*n*	4	3	1	2	0	10
	Proportion	40.0%	30.0%	10.0%	20.0%	0.0%	100%
	SE of %	16.1%	15.1%	9.9%	13.1%	0.0%	
	Number in Esc.	141	106	35	71	0	
37–45	*n*	6	7	1	2	0	16
	Proportion	37.5%	43.8%	6.3%	12.5%	0.0%	100%
	SE of %	12.4%	12.7%	6.2%	8.4%	0.0%	
	Number in Esc.	261	305	44	87	0	
Total	*n*	75	27	455	61	1	619
	Proportion	12.8%	8.0%	66.7%	12.5%	0.1%	100%
	SE of %	1.5%	1.5%	2.0%	1.7%	0.1%	
	Number in Esc.	1,645	1,029	8,577	1,603	15	12,868
	SE of number	193	189	261	218	15	

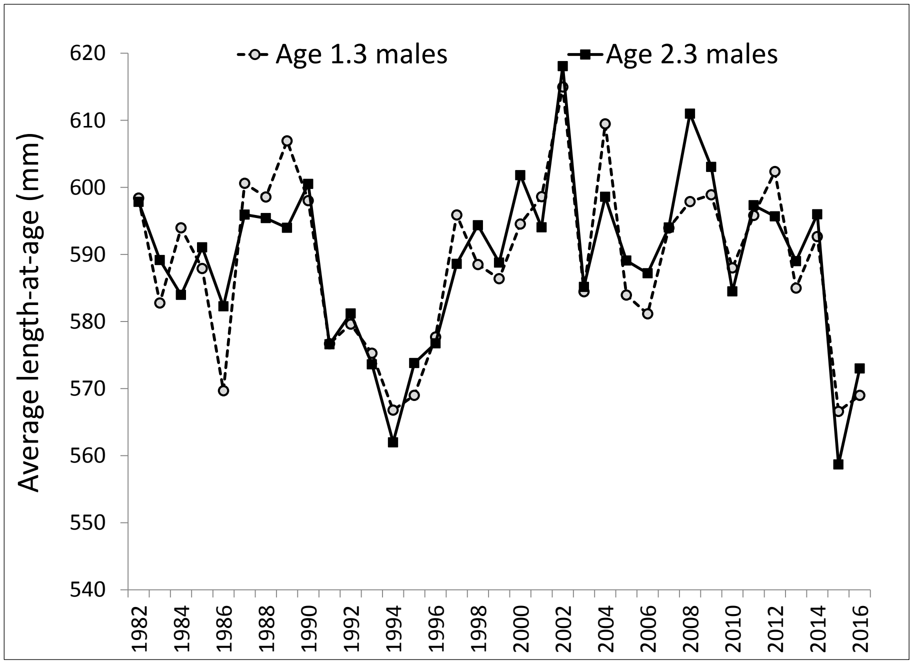

Figure 9.–Average length-at-age of ocean-age-3 male sockeye salmon sampled at the Hugh Smith Lake adult salmon weir, 1982–2016.

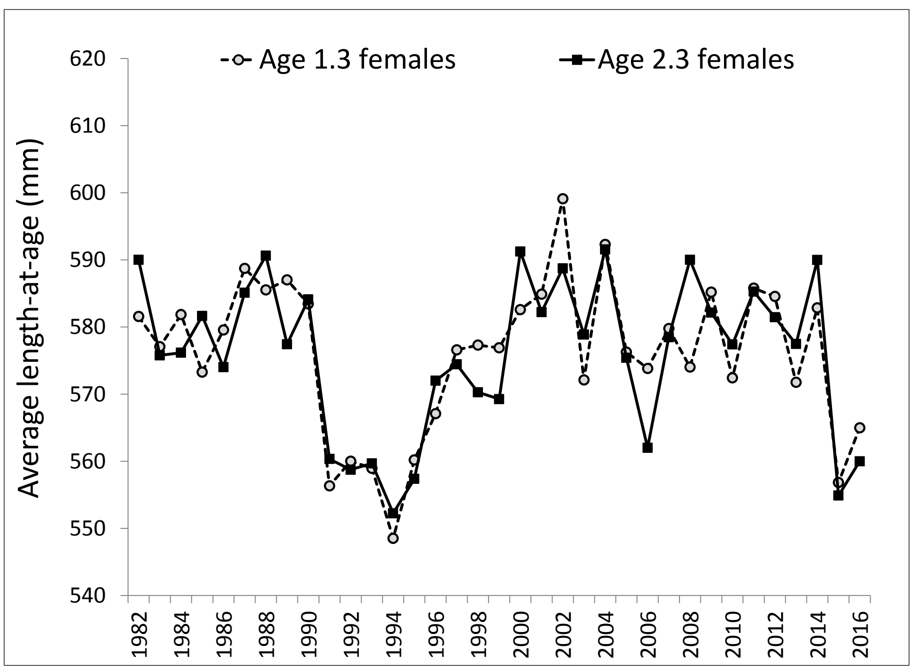

Figure 10.–Average length-at-age of ocean-age-3 female sockeye salmon sampled at the Hugh Smith Lake adult salmon weir, 1982–2016.

HARVEST

Commercial Fisheries

In 2016, approximately 35,600 (90% CI = 30,800–40,500) Hugh Smith Lake sockeye salmon were harvested in the traditional southern Southeast Alaska commercial net fisheries (Appendix F). We estimated a minimum commercial harvest rate of 73% on Hugh Smith Lake sockeye salmon. Hugh Smith Lake sockeye salmon were primarily harvested in purse seine fisheries in districts 101 (22,400 fish; Figure 11) and 104 (6,800 fish), and the Subdistrict 101-11 drift gillnet fishery (4,900 fish; Figure 12; Appendix F). In 2016, the proportion of Hugh Smith Lake sockeye salmon in the District 101 purse seine harvest peaked at 48% in statistical weeks 28–30; however, the estimated number of Hugh Smith Lake sockeye salmon harvested peaked in statistical weeks 31–32 (11,100 fish) when the harvest proportion was lower (20%; Figure 11; Appendix F). In the Subdistrict 101-11 drift gillnet fishery, the estimated contribution (1,100 fish) and proportion (35%) of Hugh Smith Lake sockeye salmon peaked in statistical week 30 in 2016 (Figure 12; Appendix F).

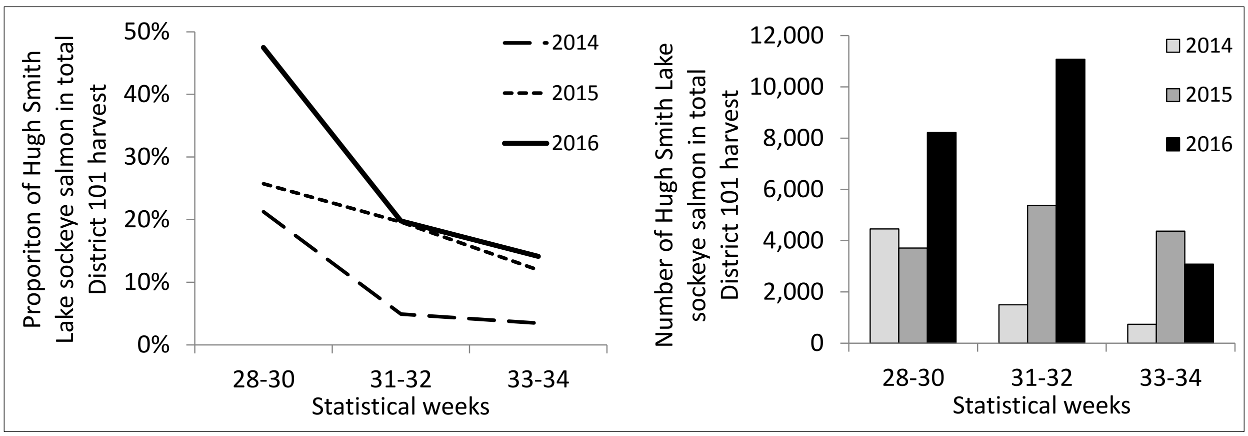

Figure 11.–Proportion of Hugh Smith Lake sockeye salmon in the total sockeye salmon harvest in the District 101 purse seine fishery (left), and estimated harvest of Hugh Smith Lake sockeye salmon in the District 101 purse seine fishery (right), 2014–2016. Statistical weeks were combined slightly differently in 2015 (statistical weeks 28–29, weeks 30–31, and weeks 32–33).

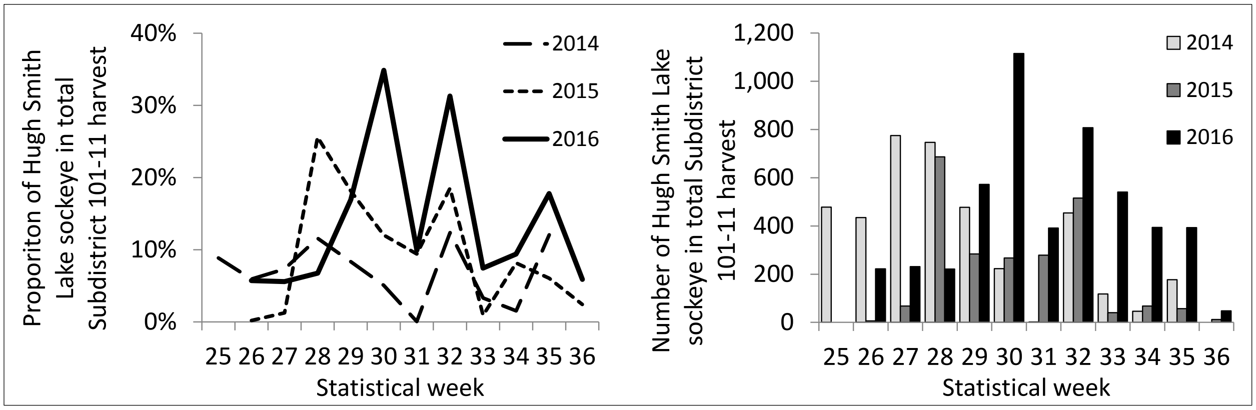

Figure 12.–Proportion of Hugh Smith Lake sockeye salmon in the total Subdistrict 101-11 drift gillnet fishery (left), and estimated harvest of Hugh Smith Lake sockeye salmon in the Subdistrict 101-11 drift gillnet fishery (right), 2014–2016.

Subsistence Fishery

The 2016 Sockeye Creek subsistence harvest of 404 sockeye salmon was lower than harvests reported in the previous four years (Figure 13). Reported fishing effort was also down from the previous four years with just 15 permits reported to have participated in the fishery. The terminal harvest rate was estimated to be 3%.

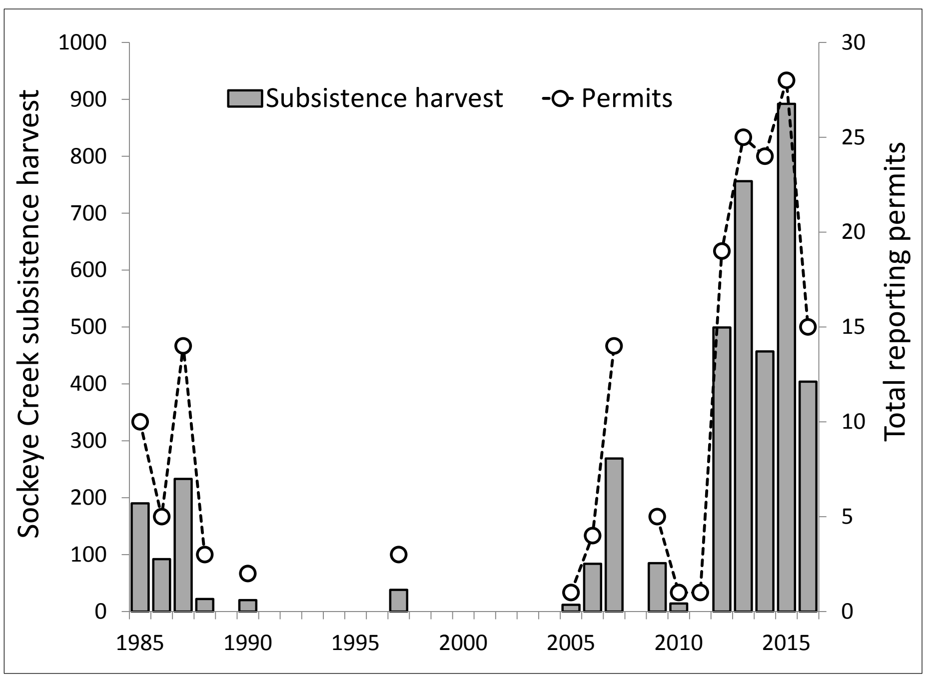

Figure 13.–Reported sockeye salmon subsistence harvests at Sockeye Creek, in the Hugh Smith Lake estuary, and number of permits fished annually, 1985–2016.

DISCUSSION

The 2016 weir count of 12,868 adult sockeye salmon was above the lower bound of the Hugh Smith Lake optimal escapement goal range of 8,000–18,000 spawners. Total escapements have now met or exceeded the goal in 12 of 14 years since 2003 (Figure 6) and have averaged 18,200 fish during that time. Escapements of wild sockeye salmon have averaged 12,000 fish since 2003. Similar to the 2015 season, the 2016 escapement started slowly. Counts averaged just 23 fish per day for the first month after the weir was installed, followed by a sharp peak in numbers beginning 24 July when more than 3,000 sockeye salmon were passed into the lake. This was very similar timing to the first large pulse of fish in 2015 (Brunette and Piston 2016). Nearly 50% of the 2016 sockeye salmon escapement passed the weir from 24 to 30 July, and the 50th and 75th percentiles of the escapement were reached approximately a week earlier than the historical (1982–2015) average.

Ocean-age-3 sockeye salmon, particularly males, were again smaller than the historical (1982–2015) average, but to a lesser degree than that observed in 2015 (Brunette and Piston 2016). Males were the third smallest on record in 2016 (smallest on record in 2015; Figure 9). Iris Frank, the ADF&G Commercial Fisheries salmon-aging laboratory supervisor (Douglas, personal communication), observed some scale reabsorption on samples collected in July but nothing as significant as was observed in 2015 (Brunette and Piston 2016). No notable deviations from historical average lengths were observed for ocean-age-2 fish in 2015 or 2016.

The 2016 count of 32,000 sockeye salmon smolt was the fourth lowest count on record (Figure 4; Table 2), but we suspect total smolt abundance was probably underestimated by a substantial degree. Smolt migration appeared to have begun early following the second warmest winter[1] and the warmest spring[2] on record in Alaska since 1925 (NOAA National Centers for Environmental Information, 2017). Foerster (1968) and Hartmann et al. (1967) summarized data that showed sockeye salmon smolt migrations begin in earnest when lake surface water temperatures rise above 4–4.4°C. The surface water temperature of Hugh Smith Lake was 7°C when the crew began installing the smolt weir, and sockeye salmon smolt were already present at the outlet and likely leaving the system before the weir was in place.

The number of coho salmon smolt counted and tagged in 2016 was also lower than usual, and roughly half the recent 20-year average of 20,500 fish (Leon Shaul, ADF&G Coho Research Biologist, personal communication). Each spring, the primary goal of the coho salmon project is to coded-wire tag all (100%) Hugh Smith Lake coho salmon smolt captured at the weir (Shaul and Crabtree 2014). Some indication of the actual proportion of the total smolt population that was captured and tagged in the spring can be obtained by examining the proportion of coded-wire-tagged jacks that return in the subsequent fall. In fall 2016 only 32% of jack coho salmon were coded-wire-tagged. Similarly, only 15% of jack coho salmon returned coded-wire-tagged in fall 2015 following the fifth warmest winter[3] and the fifth warmest spring[4] on record in Alaska (NOAA National Centers for Environmental Information, 2017). When compared to the previous 13-year average when 59% of jack coho salmon were tagged (2002–2014), the low proportion of

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1 December 2015–February 2016.
2 March 2016–May 2016.
3 December 2014–February 2015.
4 March 2015–May 2016.

tagged jacks in 2016 and 2015 suggests both coho and sockeye smolt abundance were probably greatly underestimated in those years.

Both the estimated commercial fishery contribution of Hugh Smith Lake sockeye salmon (35,600 fish) and the harvest rate (73%) were the highest of the most recent three years of estimates based on genetic stock identification (Brunette and Piston 2016). These estimates were also higher than average estimates of the contribution (13,800) and harvest rate (60.2%) generated from coded-wire tagging studies in the 1980s and 1990s (Geiger et al 2003). In the initial weeks of the District 101 purse seine fishery in 2016, Hugh Smith Lake fish accounted for 48% of the total sockeye salmon harvest and roughly 1 out of every 4 sockeye salmon caught over the course of the season. The commercial harvest rate on McDonald Lake sockeye salmon, another local wild stock located in District 101, also increased in 2016 (65%). Higher than average harvest rates on these two sockeye salmon stocks was probably due in part to more concentrated effort by the purse seine fleet in southern Southeast Alaska due to poor returns of pink salmon and little fishing opportunity in northern Southeast Alaska inside waters in 2016 (PSC 2017).

Our estimates of the 2016 commercial harvest of Hugh Smith Lake sockeye salmon represent the minimum harvest because most, but not all, fisheries were sampled. Commercial harvests outside Alaska state waters, and harvests that occurred after the peak weeks of sockeye salmon run timing, were not sampled. For example, 22,000 sockeye salmon harvested in Annette Island Reserve fisheries, in the center of District 101 where most Hugh Smith sockeye salmon are harvested, were not sampled for tissues. These fish were delivered and processed in Metlakatla and not accessible to Ketchikan-based ADF&G Port Sampling employees. We could estimate approximately 5,600 Hugh Smith Lake fish were harvested in Annette Island fisheries if we assume the proportion of Hugh Smith Lake fish in those harvests were similar to the proportions in the adjacent traditional District 101 purse seine fishery harvests. This is likely the largest undocumented harvest of this stock, and including it would increase the total commercial harvest rate by 3%. Furthermore, most traditional fishery harvests after statistical week 34 were not sampled; however, this omission likely did not have an appreciable effect on our estimates because historically only 4% of the sockeye salmon harvest occurs after statistical week 34 in southern Southeast Alaska (Districts 101–108, 1985–2016). Likewise, 79% of the sockeye salmon escapement had already entered Hugh Smith Lake by the beginning of statistical week 34 (14 August); thus, the number of Hugh Smith Lake sockeye salmon in commercial harvests would likely have been very low after statistical week 34. Finally, harvests of Hugh Smith Lake sockeye salmon in Canadian fisheries were not included in our analysis; however, due to recent declines in harvest, participation, and fishing opportunity in adjacent British Columbia fisheries, Canadian harvests of Hugh Smith Lake fish were likely minimal (PSC 2017).

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APPENDICES

Appendix A.–2016 statistical week calendar start and end dates.

Week	Start	End
1	1-Jan	2-Jan
2	3-Jan	9-Jan
3	10-Jan	16-Jan
4	17-Jan	23-Jan
5	24-Jan	30-Jan
6	31-Jan	6-Feb
7	7-Feb	13-Feb
8	14-Feb	20-Feb
9	21-Feb	27-Feb
10	28-Feb	5-Mar
11	6-Mar	12-Mar
12	13-Mar	19-Mar
13	20-Mar	26-Mar
14	27-Mar	2-Apr
15	3-Apr	9-Apr
16	10-Apr	16-Apr
17	17-Apr	23-Apr
18	24-Apr	30-Apr
19	1-May	7-May
20	8-May	14-May
21	15-May	21-May
22	22-May	28-May
23	29-May	4-Jun
24	5-Jun	11-Jun
25	12-Jun	18-Jun
26	19-Jun	25-Jun
27	26-Jun	2-Jul

Week	Start	End
28	3-Jul	9-Jul
29	10-Jul	16-Jul
30	17-Jul	23-Jul
31	24-Jul	30-Jul
32	31-Jul	6-Aug
33	7-Aug	13-Aug
34	14-Aug	20-Aug
35	21-Aug	27-Aug
36	28-Aug	3-Sep
37	4-Sep	10-Sep
38	11-Sep	17-Sep
39	18-Sep	24-Sep
40	25-Sep	1-Oct
41	2-Oct	8-Oct
42	9-Oct	15-Oct
43	16-Oct	22-Oct
44	23-Oct	29-Oct
45	30-Oct	5-Nov
46	6-Nov	12-Nov
47	13-Nov	19-Nov
48	20-Nov	26-Nov
49	27-Nov	3-Dec
50	4-Dec	10-Dec
51	11-Dec	17-Dec
52	18-Dec	24-Dec
53	25-Dec	31-Dec

The weekly age-sex distribution, the seasonal age-sex distribution weighted by week, and the mean length by age and sex weighted by week, for smolt and adults, were calculated using equations from Cochran (1977; pages 52, 107–108, and 142–144).

Let

h	=	index of the stratum (week),
j	=	index of the age class,
p_{hj}	=	proportion of the sample taken during stratum h that is age j,
n_h	=	number of fish sampled in week h, and
n_{hj}	=	number observed in class j, week h.

Then the age distribution was estimated for each week of the escapement in the usual manner:

$$\hat{p}_{hj} = n_{hj} / n_h \ . \tag{1}$$

If N_h equals the number of fish in the escapement in week h, standard errors of the weekly age class proportions are calculated in the usual manner (Cochran 1977, page 52, equation 3.12):

$$SE(\hat{p}_{hj}) = \sqrt{\left[\frac{(\hat{p}_{hj})(1-\hat{p}_{hj})}{n_h - 1}\right][1 - n_h/N_h]} \ . \tag{2}$$

The age distributions for the total escapement were estimated as a weighted sum (by stratum size) of the weekly proportions. That is,

$$\hat{p}_j = \sum_h p_{hj}(N_h/N), \tag{3}$$

such that N equals the total escapement. The standard error of a seasonal proportion is the square root of the weighted sum of the weekly variances (Cochran 1977, pages 107–108):

$$SE(\hat{p}_j) = \sqrt{\sum_j^h [SE(\hat{p}_{hj})]^2 (N_h/N)^2} \ . \tag{4}$$

The mean length, by sex and age class (weighted by week of escapement), and the variance of the weighted mean length, were calculated using the following equations from Cochran (1977, pages 142–144) for estimating means over subpopulations. That is, let i equal the index of the individual fish in the age-sex class j, and y_{hij} equal the length of the ith fish in class j, week h, so that,

$$\hat{\bar{Y}}_j = \frac{\sum_h (N_h/n_h)\sum_i y_{hij}}{\sum_h (N_h/n_h) n_{hj}} \text{, and} \tag{5}$$

$$\hat{V}\left(\hat{\bar{Y}}_j\right) = \frac{1}{\hat{N}_j^2}\sum_h \frac{N_h^2(1-n_h/N_h)}{n_h(n_h-1)}\left[\sum_i (y_{hij} - \bar{y}_{hj})^2 + n_{hj}\left(1 - \frac{n_{hj}}{n_h}\right)\left(\bar{y}_{hj} - \hat{\bar{Y}}_j\right)^2\right].$$

Appendix C.–Escapement and run timing for Hugh Smith Lake sockeye salmon, 1967–1971, and 1980–2016.

Year	1967	1968	1969	1970	1971	1980	1981	1982	1983	1984	1985
Weir Count	6,754	1,617	10,357	8,755	22,096	12,714	15,545	57,219	10,429	16,106	12,245
Total Escapement[a]	ND[b]	ND	ND	ND	ND	12,714	ND	57,219	10,429	16,106	12,245
Wild fish	6,754	1,617	10,357	8,755	22,096	12,714	15,545	57,219	10,429	16,106	12,245
Stocked fish	0	0	0	0	0	0	0	0	0	0	0
Weir Mortalities	ND	ND	ND	ND	ND	ND	ND	81	45	134	201
Adults used for egg takes	0	0	0	0	0	0	0	0	0	439	798
Spawning Escapement[c]	ND	ND	ND	ND	ND	ND	ND	57,138	10,384	15,533	11,246
Jacks (not included in weir count)[d]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Starting Date	1-Jun	13-Jun	11-Jun	9-Jun	20-Jun	5-Jun	7-Jun	4-Jun	30-May	1-Jun	1-Jun
Ending Date	3-Sep	21-Aug	14-Aug	1-Sep	22-Aug	4-Oct	8-Sep	27-Nov	30-Nov	26-Nov	11-Nov
Days Elapsed	94	69	64	84	63	121	93	176	184	178	163
Date of First Sockeye	13-Jun	14-Jun	11-Jun	11-Jun	20-Jun	6-Jun	8-Jun	7-Jun	1-Jun	6-Jun	5-Jun
Date of Last Sockeye	3-Sep	21-Aug	14-Aug	1-Sep	22-Aug	4-Oct	8-Sep	25-Oct	25-Oct	19-Nov	29-Oct
Days Elapsed for sockeye caught	82	68	64	82	63	120	92	140	146	166	146
10th Percentile Run Date	22-Jun	2-Jul	26-Jun	26-Jun	1-Jul	4-Jul	28-Jun	20-Jun	11-Jul	14-Jul	12-Jul
25th Percentile Run Date	28-Jun	11-Jul	9-Jul	6-Jul	9-Jul	20-Jul	7-Jul	29-Jun	17-Jul	26-Jul	25-Jul
50th Percentile Run Date	7-Jul	15-Aug	20-Jul	27-Jul	20-Jul	6-Aug	27-Jul	9-Jul	11-Aug	8-Aug	23-Aug
75th Percentile Run Date	18-Jul	19-Aug	7-Aug	6-Aug	19-Aug	26-Aug	24-Aug	18-Jul	4-Sep	26-Aug	2-Sep
90th Percentile Run Date	28-Jul	21-Aug	9-Aug	13-Aug	20-Aug	9-Sep	3-Sep	7-Aug	24-Sep	10-Sep	13-Sep

[a] The total escapement equals the weir count, 1980, and 1982–1987. The 1967–1971 and 1981 escapements are underestimated due to early weir removal.

[b] ND = no data.

[c] The spawning escapement equals the total estimated escapement minus weir mortalities, samples (coded-wire-tag samples), and fish killed for egg takes.

[d] Separate counts of jacks were not kept from 1967 to 2002, so those weir counts include an unknown number of jacks.

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Year	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Weir Count	2,312	33,097	5,056	6,513	1,285	5,885	65,737	11,312	8,386	3,424	7,123
Total Escapement[a]	6,968[b]	33,097	5,056	6,513	1,285	5,885	65,737	13,532	8,992	3,452	7,123
Wild fish	6,968	33,097	5,056	ND[cd]	ND[d]	ND[d]	ND[d]	ND[d]	ND[d]	ND[d]	ND[d]
Stocked fish	0	0	0	ND[d]	ND[d]	ND[d]	ND[d]	ND[d]	ND[d]	ND[d]	ND[d]
Weir Mortalities	12	0	28	32	28	33	151	278	42	11	57
Adults used for egg takes	619	1,902	424	1,547	0	357	178	1,460	763	312	513
Spawning Escapement[e]	6,337	31,195	4,604	4,934	1,257	5,495	65,408	11,794	8,187	3,129	6,553
Jacks (not included in weir count)[f]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Starting Date	17-Jun	3-Jun	5-Jun	3-Jun	8-Jun	17-Jun	16-Jun	17-Jun	20-Jun	17-Jun	17-Jun
Ending Date	29-Oct	21-Oct	22-Oct	25-Oct	31-Oct	9-Oct	25-Oct	4-Nov	1-Nov	3-Nov	4-Nov
Days Elapsed	134	140	139	144	145	114	131	140	134	139	140
Date of First Sockeye	18-Jun	8-Jun	12-Jun	11-Jun	13-Jun	19-Jun	16-Jun	20-Jun	20-Jun	19-Jun	20-Jun
Date of Last Sockeye	3-Oct	4-Oct	16-Oct	18-Oct	21-Oct	11-Oct	18-Oct	3-Nov	26-Oct	1-Nov	20-Oct
Days Elapsed for sockeye caught	107	118	126	129	130	114	124	136	128	135	122
10th Percentile Run Date	11-Jul	18-Jul	19-Jul	30-Jul	8-Jul	22-Jul	12-Jul	2-Jul	20-Jul	7-Jul	25-Jul
25th Percentile Run Date	15-Jul	20-Jul	24-Jul	5-Aug	23-Jul	29-Jul	19-Jul	16-Jul	1-Aug	17-Jul	11-Aug
50th Percentile Run Date	20-Jul	4-Aug	9-Aug	10-Aug	27-Aug	21-Aug	27-Jul	30-Jul	23-Aug	29-Jul	19-Aug
75th Percentile Run Date	28-Jul	30-Aug	25-Aug	14-Aug	7-Sep	12-Sep	29-Jul	14-Aug	26-Aug	9-Aug	3-Sep
90th Percentile Run Date	8-Aug	31-Aug	1-Sep	22-Aug	16-Sep	22-Sep	11-Aug	31-Aug	3-Sep	21-Aug	13-Sep

[a] The total escapement equals the weir count or mark–recapture estimate (1993, 1994, 1995) plus weir mortalities.

[b] Data used to calculate a Petersen mark–recapture estimate in 1986 are no longer available.

[c] ND = no data.

[d] Escapements were not separated into numbers of wild and stocked fish from 1989 to 2002.

[e] The spawning escapement equals the total estimated escapement minus weir mortalities, samples (coded-wire-tag samples), and fish killed for egg takes.

[f] Separate counts of jacks were not kept from 1967 to 2001, so those weir counts include an unknown number of jacks.

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Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Weir Count	12,182	1,138	3,174	4,281	3,665	6,166	19,588	19,930	24,108	42,529	34,077
Total Escapement[a]	12,182	1,138	3,174	4,281	3,825	6,166	19,588	19,930	24,108	42,529	34,077
Wild fish	ND[bc]	ND[c]	ND[c]	ND[c]	ND[c]	ND[c]	6,856	6,976	10,366	14,993	13,713
Stocked fish	ND[c]	ND[c]	ND[c]	ND[c]	ND[c]	ND[c]	12,732	12,955	13,742	27,537	20,364
Weir Mortalities	28	23	20	12	6	0	20	196	236	418	334
Adults used for egg takes	0	218	276	280	268	286	0	0	0	0	0
Spawning Escapement[d]	12,154	897	2,878	3,989	3,551	5,880	19,568	19,734	23,872	42,112	33,743
Jacks (not included in weir count)	ND[e]	ND[e]	ND[e]	ND[e]	ND[e]	167	1,356	147	331	4	236
Starting Date	18-Jun	17-Jun	16-Jun	17-Jun	16-Jun	17-Jun	17-Jun	17-Jun	17-Jun	17-Jun	17-Jun
Ending Date	5-Nov	11-Nov	8-Nov	11-Nov	11-Nov	4-Nov	7-Nov	7-Nov	4-Nov	7-Nov	4-Nov
Days Elapsed	140	147	145	147	148	140	146	142	143	143	140
Date of First Sockeye	18-Jun	19-Jun	22-Jun	19-Jun	19-Jun	19-Jun	19-Jun	18-Jun	19-Jun	19-Jun	18-Jun
Date of Last Sockeye	1-Nov	12-Oct	4-Oct	27-Oct	6-Oct	17-Oct	2-Nov	31-Oct	22-Oct	3-Nov	26-Oct
Days Elapsed for sockeye caught	136	115	104	130	109	120	136	135	125	137	130
10th Percentile Run Date	3-Jul	8-Jul	7-Jul	29-Jun	2-Jul	10-Jul	2-Aug	8-Jul	17-Jul	1-Aug	19-Jul
25th Percentile Run Date	16-Jul	21-Jul	15-Jul	7-Jul	18-Jul	4-Aug	17-Aug	4-Aug	31-Jul	4-Aug	16-Aug
50th Percentile Run Date	25-Jul	30-Jul	31-Jul	20-Jul	17-Aug	7-Aug	21-Aug	6-Aug	20-Aug	9-Aug	28-Aug
75th Percentile Run Date	2-Aug	10-Aug	15-Aug	30-Jul	22-Aug	9-Aug	28-Aug	29-Aug	26-Aug	15-Aug	1-Sep
90th Percentile Run Date	15-Aug	18-Aug	22-Aug	6-Aug	23-Aug	12-Aug	2-Sep	2-Sep	3-Sep	26-Aug	7-Sep

[a] The total escapement equals the weir count or mark–recapture estimate (2001) plus weir mortalities.

[b] ND = no data.

[c] Escapements were not separated into numbers of wild and stocked fish from 1989 to 2002.

[d] The spawning escapement equals the total estimated escapement minus weir mortalities, samples (otolith samples), and fish killed for egg takes.

[e] Separate counts of jacks were not kept from 1967 to 2001, so those weir counts include an unknown number of jacks.

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Year	2008	2009	2010	2011	2012	2013	2014	2015	2016
Weir Count	3,590	9,483	15,646	22,029	13,353	5,946	10,397	21,298	12,868
Total Escapement[a]	3,590	9,483	15,646	22,029	13,353	5,946	10,397	21,298	12,868
Wild fish	3,590	9,483	15,646	22,029	13,353	5,946	10,397	21,298	12,868
Stocked fish	0	0	0	0	0	0	0	0	0
Weir Mortalities	2	0	0	0	0	0	0	2	3
Adults used for egg takes	0	0	0	0	0	0	0	0	0
Spawning Escapement[b]	3,588	9,483	15,646	22,029	13,353	5,946	10,397	21,296	12,865
Jacks (not included in weir count)	260	301	158	46	46	275	350	125	93
Starting Date	17-Jun	16-Jun	16-Jun	17-Jun	16-Jun	18-Jun	17-Jun	18-Jun	16-Jun
Ending Date	3-Nov	8-Nov	8-Nov	11-Nov	10-Nov	10-Nov	9-Nov	5-Nov	13-Nov
Days Elapsed	139	145	146	147	147	146	146	140	149
Date of First Sockeye	19-Jun	18-Jun	18-Jun	19-Jun	18-Jun	19-Jun	18-Jun	20-Jun	20-Jun
Date of Last Sockeye	28-Oct	5-Oct	4-Oct	8-Nov	1-Nov	17-Oct	17-Oct	26-Oct	3-Nov
Days Elapsed for sockeye caught	131	110	110	142	137	121	122	128	136
10^{th} Percentile Run Date	16-Jul	4-Jul	5-Jul	11-Jul	1-Jul	17-Jun	2-Jul	25-Jul	24-Jul
25^{th} Percentile Run Date	26-Jul	10-Jul	23-Jul	23-Jul	10-Jul	19-Jul	22-Jul	27-Jul	24-Jul
50^{th} Percentile Run Date	31-Jul	23-Jul	24-Jul	28-Jul	22-Jul	25-Jul	28-Jul	5-Aug	27-Jul
75^{th} Percentile Run Date	14-Aug	11-Aug	29-Jul	16-Aug	1-Aug	27-Jul	31-Jul	16-Aug	13-Aug
90^{th} Percentile Run Date	24-Aug	13-Aug	11-Aug	19-Aug	8-Aug	22-Aug	12-Aug	27-Aug	22-Aug

[a] The total escapement equals the weir count or mark–recapture estimate (2001) plus weir mortalities.

[b] The spawning escapement equals the total estimated escapement minus weir mortalities, samples (otolith samples), and fish killed for egg takes.

Appendix D.–Mark–recapture estimates for Hugh Smith Lake sockeye salmon, 1992–2016.

Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Live Weir Count[a]	**65,586**[b]	11,034	8,344	3,413	**7,066**	**12,154**	**1,115**	**3,154**	**4,269**	3,629	**5,999**[b]	**19,568**
Proportion Marked	36%	99%	97%	100%	99%	67%	67%	67%	67%	50%	50%	10%
Fish Marked	23,790	10,973	8,126	3,396	6,995	8,100	745	2,103	2,846	1,807	2,999	1,945
Fish Sampled for Marks	1,974	2,377	1,152	1,028	374	934	226	323	443	484	908	2,057
Marked Fish Recovered	814	2,029	1,041	1,006	369	638	157	221	299	230	449	194
Method	PPE[c]	ML Darroch[d]	ML Darroch[d]	ML Darroch[d]	PPE	PPE	PPE	PPE	PPE	PPE	PPE	PPE
Estimate[e]	57,652	**13,254**	**8,925**	**3,441**	7,090	11,853	1,071	3,070	4,213	**3,789**	6,059	20,537
SE	1,520	134	77	70	41	253	42	109	131	168	187	1,324
+/-95% CI	2,979	263	151	137	80	496	82	214	257	329	367	2,595
CV	3%	1%	1%	2%	1%	2%	4%	4%	3%	4%	3%	6%

[a] The weir count used for the mark–recapture calculations was the number of live fish passed through the weir (weir count minus weir mortalities).

[b] Boldfaced estimates were used as the official escapement estimate for that year.

[c] PPE = Pooled Peterson Estimate

[d] Chi-square tests for goodness of fit and complete mixing in 1993, 1994, and 1995 were highly significant and suggest that the ML Darroch estimates should be used rather than a Pooled Petersen estimate.

[e] Pooled Petersen and ML Darroch estimates and their standard errors were calculated using Stratified Population Analysis Software. Release data were stratified into three release periods and recovery data were stratified by recovery days.

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Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Live Weir Count[a]	**19,734**[b]	**23,872**	**42,112**	**33,743**	**3,588**	**9,483**	**15,646**	**22,029**	**13,353**	**5,946**	**10,397**	**21,296**	**12,865**
Proportion Marked	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	12%	10%
Fish Marked	1,979	2,278	4,208	3,414	358	949	1,565	2,202	1,335	595	1,039	2,515	1,297
Fish Sampled for Marks	1,547	1,244	2,187	1,764	659	1,271	3,652	2,490	2,199	1,714	1,326	1,590	1,008
Marked Fish Recovered	136	115	229	176	50	123	339	242	196	138	134	161	94
Method	ML Darroch	PPE[c]	PPE	PPE	PPE	PPE	PPE	PPE	PPE	ML Darroch	PPE	PPE	PPE
Estimate[d]	21,950	24,459	40,039	34,053	4,645	9,744	16,824	22,582	14,919	6,363	10,222	24,709	13,785
SE	1,991	2,098	2,423	2,357	573	772	768	1,295	934	623	775	1,774	1,289
+/-95% CI[e]	4,000	4,112	4,749	4,621	1,123	1,513	1,505	2,539	1,831	1,221	1,519	21,533–28,540	11,538–16,655
CV	9%	9%	6%	7%	12%	8%	5%	6%	6%	10%	8%	7%	9%

[a] The weir count used for the mark–recapture calculations was the number of live fish passed through the weir (weir count minus weir mortalities).

[b] Boldfaced estimates were used as the official escapement estimate for that year.

[c] PPE = Pooled Peterson Estimate

[d] Pooled Petersen and ML Darroch estimates and their standard errors were calculated using Stratified Population Analysis Software. Release data were stratified into three release periods and recovery data were stratified by recovery days.

[e] Normal distribution 95% confidence intervals are presented prior to 2015. Transform-based 95% confidence intervals are presented for 2015 and 2016.

Appendix E.–Age distribution of the Hugh Smith Lake sockeye salmon escapement, weighted by week, 1980–2016.

		Age Class																
Return Year		0.1	1.1	2.1	3.1	0.2	1.2	2.2	3.2	0.3	1.3	2.3	3.3	1.4	2.4	1.5	2.5	Total
1980	Number by Age Class		37				1,055	113			9,380	2,129						12,714
	SE of Number		21				139	33			200	156						
	Proportion by Age Class		0.3%				8.3%	0.9%			73.8%	16.7%						
	SE of Proportion		0.2%				1.1%	0.3%			1.6%	1.2%						
	Sample Size		3				72	12			719	175						981
1981	Number by Age Class		250				7,216	1,826			4,598	1,655						15,545
	SE of Number		55				208	126			204	119						
	Proportion by Age Class		1.6%				46.4%	11.7%			29.6%	10.6%						
	SE of Proportion		0.4%				1.3%	0.8%			1.3%	0.8%						
	Sample Size		19				502	149			338	137						1,145
1982	Number by Age Class						1,613	805		12	52,124	2,665						57,219
	SE of Number						155	115		11	205	118						
	Proportion by Age Class						2.8%	1.4%		0.0%	91.1%	4.7%						
	SE of Proportion						0.3%	0.2%		0.0%	0.4%	0.2%						
	Sample Size						174	122		1	2,305	407						3,009
1983	Number by Age Class		14	8			1,375	495		12	5,501	2,843		182				10,429
	SE of Number		14	7			98	62		8	169	157		38				
	Proportion by Age Class		0.1%	0.1%			13.2%	4.7%		0.1%	52.7%	27.3%		1.7%				
	SE of Proportion		0.1%	0.1%			0.9%	0.6%		0.1%	1.6%	1.5%		0.4%				
	Sample Size		1	1			157	57		2	565	301		23				1,107
1984	Number by Age Class		9				966	551			10,436	4,144						16,106
	SE of Number		9				77	70			153	137						
	Proportion by Age Class		0.1%				6.0%	3.4%			64.8%	25.7%						
	SE of Proportion		0.1%				0.5%	0.4%			0.9%	0.9%						
	Sample Size		1				149	56			1,007	378						1,591
1985	Number by Age Class			15			76	43			8,935	2,997	13	74	70		23	12,245
	SE of Number			14			23	17			151	147	9	31	28		13	
	Proportion by Age Class			0.1%			0.6%	0.3%			73.0%	24.5%	0.1%	0.6%	0.6%		0.2%	
	SE of Proportion			0.1%			0.2%	0.1%			1.2%	1.2%	0.1%	0.3%	0.2%		0.1%	
	Sample Size			1			10	6			856	279	2	6	7		3	1,170
1986	Number by Age Class		5			4	5,076	780			745	305		49		5		6,968
	SE of Number	0	3			1	28	25			25	18		6		3		
	Proportion by Age Class		0.1%			0.1%	72.8%	11.2%			10.7%	4.4%		0.7%		0.1%		
	SE of Proportion		0.0%			0.0%	0.4%	0.4%			0.4%	0.3%		0.1%		0.0%		
	Sample Size		1			1	1,389	191			195	77		13		1		1,868

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Return Year		0.1	1.1	2.1	3.1	0.2	1.2	2.2	3.2	0.3	1.3	2.3	3.3	1.4	2.4	1.5	2.5	Total
		Age Class																
1987	Number by Age Class		147	130			626	1,030	24		29,329	1,733	61	17				33,097
	SE of Number		68	49			112	133	11		257	187	45	17				
	Proportion by Age Class		0.4%	0.4%			1.9%	3.1%	0.1%		88.6%	5.2%	0.2%	0.1%				
	SE of Proportion		0.2%	0.1%			0.3%	0.4%	0.0%		0.8%	0.6%	0.1%	0.1%				
	Sample Size		9	18			66	132	4		3,374	278	6	1				3,888
1988	Number by Age Class		5	3			1,907	1,237			1,054	782	2	67				5,056
	SE of Number		2	1			31	27			26	21	2	6				
	Proportion by Age Class		0.1%	0.1%			37.7%	24.5%			20.8%	15.5%	0.0%	1.3%				
	SE of Proportion		0.0%	0.0%			0.6%	0.5%			0.5%	0.4%	0.0%	0.1%				
	Sample Size		3	2			1,076	727			624	499	1	46				2,978
1989	Number by Age Class						163	52	1		5,808	486	1		2			6,513
	SE of Number						11	11	0		37	35	0		2			
	Proportion by Age Class						2.5%	0.8%	0.0%		89.2%	7.5%	0.0%		0.0%			
	SE of Proportion						0.2%	0.2%	0.0%		0.6%	0.5%	0.0%		0.0%			
	Sample Size						116	24	1		1,489	184	1		1			1,816
1990	Number by Age Class		12	1			52	38			658	495	1	27				1,285
	SE of Number		3	1			6	4			14	14	0	2				
	Proportion by Age Class		0.9%	0.1%			4.1%	3.0%			51.2%	38.5%	0.1%	2.1%				
	SE of Proportion		0.2%	0.0%			0.4%	0.3%			1.1%	1.1%	0.0%	0.1%				
	Sample Size		8	1			39	29			537	294	1	24				933
1991	Number by Age Class		2	26	4		1,588	2,028	2		781	1,442			13			5,885
	SE of Number		0	8	3		16	31	1		15	30			4			
	Proportion by Age Class		0.0%	0.4%	0.1%		27.0%	34.5%	0.0%		13.3%	24.5%			0.2%			
	SE of Proportion		0.0%	0.1%	0.1%		0.3%	0.5%	0.0%		0.3%	0.5%			0.1%			
	Sample Size		2	11	1		1,274	1,103	1		629	998			8			4,027
1992	Number by Age Class		3	3			1,587	1,262	15		60,690	1,824		336	15			65,737
	SE of Number		3	3			436	156	15		628	360		286	13			
	Proportion by Age Class		0.0%	0.0%			2.4%	1.9%	0.0%		92.3%	2.8%		0.5%	0.0%			
	SE of Proportion		0.0%	0.0%			0.7%	0.2%	0.0%		1.0%	0.5%		0.4%	0.0%			
	Sample Size		1	1			63	105	1		914	135		2	2			1,224
1993	Number by Age Class			13			1,137	1,916	10		3,055	7,038	66	285	13			13,532
	SE of Number			7			142	159	8		167	215	44	48	10			
	Proportion by Age Class			0.1%			8.4%	14.2%	0.1%		22.6%	52.0%	0.5%	2.1%	0.1%			
	SE of Proportion			0.1%			1.3%	1.4%	0.1%		1.5%	1.9%	0.4%	0.4%	0.1%			
	Sample Size			2			62	163	1		279	564	2	31	1			1,105

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Return Year		0.1	1.1	2.1	3.1	0.2	1.2	2.2	3.2	0.3	1.3	2.3	3.3	1.4	2.4	1.5	2.5	Total
		Age Class																
1994	Number by Age Class		51	41			572	625	6		6,546	1,079		66	5	2		8,992
	SE of Number		23	14			73	88	4		139	95		18	3	1		
	Proportion by Age Class		0.6%	0.5%			6.4%	7.0%	0.1%		72.8%	12.0%		0.7%	0.1%	0.0%		
	SE of Proportion		0.3%	0.2%			0.8%	1.0%	0.0%		1.5%	1.1%		0.2%	0.0%	0.0%		
	Sample Size		12	13			148	91	2		966	243		18	2	1		1,496
1995	Number by Age Class			25			902	451			802	1,226		44	1			3,452
	SE of Number			6			47	38			44	49		14	0			
	Proportion by Age Class			0.7%			26.1%	13.1%			23.2%	35.5%		1.3%	0.0%			
	SE of Proportion			0.2%			1.4%	1.1%			1.3%	1.4%		0.4%	0.0%			
	Sample Size			16			299	133			263	408		13	1			1,133
1996	Number by Age Class		12				1,012	1,654	6		3,519	904			16			7,123
	SE of Number		8				125	176	5		175	139			16			
	Proportion by Age Class		0.2%				14.2%	23.2%	0.1%		49.4%	12.7%			0.2%			
	SE of Proportion		0.1%				1.8%	2.5%	0.1%		2.5%	1.9%			0.2%			
	Sample Size		2				97	76	1		287	70			1			534
1997	Number by Age Class		18				249	404			10,793	664	20	35				12,182
	SE of Number		18				68	83			144	101	19	24				
	Proportion by Age Class		0.1%				2.0%	3.3%			88.6%	5.5%	0.2%	0.3%				
	SE of Proportion		0.1%				0.6%	0.7%			1.2%	0.8%	0.2%	0.2%				
	Sample Size		1				13	22			580	37	1	2				656
1998	Number by Age Class		27	9		3	75	49			576	332		66				1,138
	SE of Number		18	3		2	26	19			54	50		30				
	Proportion by Age Class		2.4%	0.8%		0.3%	6.6%	4.3%			50.6%	29.2%		5.8%				
	SE of Proportion		1.5%	0.3%		0.2%	2.3%	1.6%			4.7%	4.4%		2.7%				
	Sample Size		2	3		1	9	7			81	32		5				140
1999	Number by Age Class			29			1,658	538			573	363		6	7			3,174
	SE of Number			14			67	52			53	43		5	6			
	Proportion by Age Class			0.9%			52.2%	17.0%			18.1%	11.4%		0.2%	0.2%			
	SE of Proportion			0.4%			2.1%	1.6%			1.7%	1.4%		0.2%	0.2%			
	Sample Size			4			245	77			81	53		1	1			462
2000	Number by Age Class		14		13		918	302			2,251	769	14					4,281
	SE of Number		13		12		86	52			103	82	13					
	Proportion by Age Class		0.3%		0.3%		21.4%	7.1%			52.6%	18.0%	0.3%					
	SE of Proportion		0.3%		0.3%		2.0%	1.2%			2.4%	1.9%	0.3%					
	Sample Size		1		1		94	33			257	70	1					457

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		Age Class																
Return Year		0.1	1.1	2.1	3.1	0.2	1.2	2.2	3.2	0.3	1.3	2.3	3.3	1.4	2.4	1.5	2.5	Total
2001	Number by Age Class	7	60			6	162	71			2,908	598		7	6			3,825
	SE of Number	6	18			6	34	18			60	49		6	6			
	Proportion by Age Class	0.2%	1.6%			0.2%	4.2%	1.9%			76.0%	15.6%		0.2%	0.2%			
	SE of Proportion	0.2%	0.5%			0.1%	0.9%	0.5%			1.6%	1.3%		0.2%	0.1%			
	Sample Size	1	9			1	25	14			591	120		1	1			763
2002	Number by Age Class		6	21			3,981	564			1,318	263		13				6,166
	SE of Number		6	11			89	58			76	41		9				
	Proportion by Age Class		0.1%	0.3%			64.6%	9.2%			21.4%	4.3%		0.2%				
	SE of Proportion		0.1%	0.2%			1.4%	0.9%			1.2%	0.7%		0.1%				
	Sample Size		1	3			582	77			197	36		2				898
2003	Number by Age Class		42	67		14	10,028	840	18	136	7,385	1,059						19,588
	SE of Number		23	28		13	287	121	17	44	276	129						
	Proportion by Age Class		0.2%	0.3%		0.1%	51.2%	4.3%	0.1%	0.7%	37.7%	5.4%						
	SE of Proportion		0.1%	0.1%		0.1%	1.5%	0.6%	0.1%	0.2%	1.4%	0.7%						
	Sample Size		3	5		1	622	50	1	9	437	65						1,193
2004	Number by Age Class		523	36			8,623	1,695			8,362	690						19,930
	SE of Number		102	25			339	196			341	113						
	Proportion by Age Class		2.6%	0.2%			43.3%	8.5%			42.0%	3.5%						
	SE of Proportion		0.5%	0.1%			1.7%	1.0%			1.7%	0.6%						
	Sample Size		25	2			385	84			387	39						922
2005	Number by Age Class			26			6,696	1,566		18	14,264	1,537						24,108
	SE of Number			18			267	152		18	296	150						
	Proportion by Age Class			0.1%			27.8%	6.5%		0.1%	59.2%	6.4%						
	SE of Proportion			0.1%			1.1%	0.6%		0.1%	1.2%	0.6%						
	Sample Size			2			440	98		1	900	97						1,538
2006	Number by Age Class						20,815	3,467			16,642	1,604						42,529
	SE of Number						1,029	488			1,000	303						
	Proportion by Age Class						48.9%	8.2%			39.1%	3.8%						
	SE of Proportion						2.4%	1.1%			2.4%	0.7%						
	Sample Size						314	102			357	46						819
2007	Number by Age Class						2,266	592			25,915	5,304						34,077
	SE of Number						383	188			655	555						
	Proportion by Age Class						6.6%	1.7%			76.0%	15.6%						
	SE of Proportion						1.1%	0.6%			1.9%	1.6%						
	Sample Size						34	11			494	96						635

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Return Year		Age Class 0.1	1.1	2.1	3.1	0.2	1.2	2.2	3.2	0.3	1.3	2.3	3.3	1.4	2.4	1.5	2.5	Total
2008	Number by Age Class						1,437	855			708	445		129	16			3,590
	SE of Number						90	77			77	60		35	16			
	Proportion by Age Class						40.0%	23.8%			19.7%	12.4%		3.6%	0.4%			
	SE of Proportion						2.5%	2.1%			2.1%	1.7%		1.0%	0.4%			
	Sample Size						140	90			67	44		13	1			355
2009	Number by Age Class						2,407	1,588			4,397	1,091						9,483
	SE of Number						151	135			174	118						
	Proportion by Age Class						25.4%	16.7%			46.4%	11.5%						
	SE of Proportion						1.6%	1.4%			1.8%	1.2%						
	Sample Size						186	106			342	75						709
2010	Number by Age Class						3,020	2,762	17		7,987	1,728	120	12				15,646
	SE of Number						199	188	17		247	158	48	11				
	Proportion by Age Class						19.3%	17.7%	0.1%		51.0%	11.0%	0.8%	0.1%				
	SE of Proportion						1.3%	1.2%	0.1%		1.6%	1.0%	0.3%	0.1%				
	Sample Size						184	144	1		499	107	6	1				942
2011	Number by Age Class						796	9,019	11		7,898	4,261		43				22,029
	SE of Number						118	313	11		285	261		26				
	Proportion by Age Class						3.6%	40.9%	0.1%		35.9%	19.3%		0.2%				
	SE of Proportion						0.5%	1.4%	0.0%		1.3%	1.2%		0.1%				
	Sample Size						47	447	1		496	215		3				1,209
2012	Number by Age Class						313	1,370	43		3,927	7,629		50	22			13,353
	SE of Number						84	163	30		241	266		34	0			
	Proportion by Age Class						2.3%	10.3%	0.3%		29.4%	57.1%		0.4%	0.2%			
	SE of Proportion						0.6%	1.2%	0.2%		1.8%	2.0%		0.3%				
	Sample Size						13	59	2		175	335		2	1			587
2013	Number by Age Class						1,689	406	14		300	3,485	33	21				5,946
	SE of Number						119	63	14		56	130	18	14				
	Proportion by Age Class						28.4%	6.8%	0.2%		5.0%	58.6%	0.6%	0.3%				
	SE of Proportion						2.0%	1.1%	0.2%		0.9%	2.2%	0.3%	0.2%				
	Sample Size						135	38	1		26	297	3	2				502
2014	Number by Age Class		20	71			3,319	1,333			5,376	278						10,397
	SE of Number		19	41			195	143			202	65						
	Proportion by Age Class		0.2%	0.7%			31.9%	12.8%			51.7%	2.7%						
	SE of Proportion		0.2%	0.4%			1.9%	1.4%			1.9%	0.6%						
	Sample Size		1	3			196	69			351	18						638

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Return Year		Age Class																
		0.1	1.1	2.1	3.1	0.2	1.2	2.2	3.2	0.3	1.3	2.3	3.3	1.4	2.4	1.5	2.5	Total
2015	Number by Age Class			12			6,010	4,815	24		8,835	1,559		41				21,298
	SE of Number			12			323	291	16		369	201		41				
	Proportion by Age Class			0.1%			28.2%	22.6%	0.1%		41.5%	7.3%		0.2%				
	SE of Proportion			0.1%			1.5%	1.4%	0.1%		1.7%	0.9%		0.2%				
	Sample Size			1			261	253	2		380	66		1				964
2016	Number by Age Class						1,645	1,029			8,577	1,603		15				12,868
	SE of Number						193	189			261	218		15				
	Proportion by Age Class						12.8%	8.0%			66.7%	12.5%		0.1%				
	SE of Proportion						1.5%	1.5%			2.0%	1.7%		0.1%				
	Sample Size						75	27			455	61		1				619

Appendix F.–Proportional stock composition estimates, standard deviation (SD), 90% or 95% credibility intervals (CI), and total harvest estimates of Hugh Smith Lake sockeye salmon in the Districts 101–104 purse seine fisheries and in the Districts 106, 108, and Subdistrict 101-11 drift gillnet fisheries in 2016 based on genetic mixed stock analysis. *Note*: Not all harvest was sampled in all strata.

						Hugh Smith Lake sockeye salmon harvest contribution					
								90% CI			
Year	Gear	District-subdistrict	Stat weeks	Harvest	MSA sample size	Estimated proportion	SD	Lower	Upper	Point Estimate	Harvest SD
2016	Gillnet	106-30	25–36	33,559	2,877	0.4%	0.3%	0.0%	1.1%	134	101
2016	Gillnet	106-30	37–39	136	0	ND	ND	ND	ND	ND	ND
2016	Gillnet	106-41	25–34, 36	71,679	2,486	0.5%	0.3%	0.1%	1.1%	358	215
2016	Gillnet	106-41	35, 37–39	1,275	0	ND	ND	ND	ND	ND	ND
2016	Gillnet	108	25–36	70,104	3,850	0.0%	0.1%	0.0%	0.2%	0	70
2016	Gillnet	108	37–39	39	0	ND	ND	ND	ND	ND	ND
2016	Seine	101	28–30	17,309	199	47.5%	4.1%	40.5%	54.0%	8,220	711
2016	Seine	101	31–32	55,972	370	19.8%	2.9%	15.2%	24.6%	11,075	1,603
2016	Seine	101	33–34	21,853	198	14.1%	4.0%	8.0%	20.9%	3,085	867
2016	Seine	102	26–30, 32–33	49,900	476	2.0%	0.6	1.1	3.2	1,009	320
2016	Seine	102	31, 34–38	2,378	0	ND	ND	ND	ND	ND	ND
2016	Seine	103	30–34	16,640	314	0.0%	0.1%	0.0%	0.0%	1	12

[a] ND = No data.

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					MSA	Hugh Smith Lake sockeye salmon harvest contribution					
		District-	Stat		sample	Estimated		95% CI		Point	
Year	Gear	subdistrict	weeks	Harvest	size	proportion	SD	Lower	Upper	Estimate	Harvest SD
2016	Gillnet	101-11	26	3,882	260	5.72%	1.7%	2.8%	9.3%	222	64
2016	Gillnet	101-11	27	4,138	260	5.58%	1.8%	2.5%	9.3%	231	73
2016	Gillnet	101-11	28	3,286	260	6.73%	2.0%	3.3%	11.0%	221	65
2016	Gillnet	101-11	29	3,380	241	16.92%	3.6%	10.3%	24.6%	572	123
2016	Gillnet	101-11	30	3,200	254	34.84%	4.2%	26.8%	43.0%	1,115	133
2016	Gillnet	101-11	31	3,945	260	9.92%	2.9%	4.6%	15.7%	391	113
2016	Gillnet	101-11	32	2,581	260	31.28%	4.5%	22.8%	40.7%	807	117
2016	Gillnet	101-11	33	7,257	260	7.45%	2.7%	2.6%	13.0%	541	194
2016	Gillnet	101-11	34	4,199	260	9.38%	2.1%	5.5%	13.7%	394	88
2016	Gillnet	101-11	35	2,210	233	17.78%	2.9%	12.3%	23.8%	393	65
2016	Gillnet	101-11	36	810	219	5.89%	2.7%	0.0%	11.6%	48	22
2016	Gillnet	101-11	37–40	1,024	0	ND [a]	ND	ND	ND	ND	ND
2016	Seine	104	28	27,951	260	7.29%	2.6%	2.8%	12.9%	2,038	738
2016	Seine	104	29	71,681	300	2.20%	1.5%	0.0%	5.5%	1,577	1090
2016	Seine	104	30	10,714	16	ND	ND	ND	ND	ND	ND
2016	Seine	104	31	71,087	264	2.98%	1.5%	0.5%	6.4%	2,118	1066
2016	Seine	104	32	177,143	260	0.30%	0.7%	0.0%	2.3%	531	1169
2016	Seine	104	33	32,687	262	0.63%	1.4%	0.0%	4.9%	206	454
2016	Seine	104	34	14,726	290	2.27%	1.8%	0.0%	6.1%	334	269
									Minimum Commercial Harvest	35,621	2,937
									Commercial Harvest 90% CI		30,789–40,453
									Escapement		12,868
									Minimum Commercial Harvest Rate		73%
									Commercial Harvest Rate 90% CI		71%–76%

[a] ND = No data.